

Compressed Air Magazine

Vol. 40, No. 9

London - New York - Paris

September, 1935



CONVEYOR DISCHARGING SPOIL FROM
EXCAVATION FOR GRAND COULEE DAM

I-R POTT IMPACT WRENCH



ONE-MAN AIR WRENCH.
OUT PERFORMS OLDER
MACHINES THREE TIMES
ITS WEIGHT

Ingersoll-Rand Pneumatic Tools
include:

Riveters	Saws
Chippers	Wrenches
Drills	Air Motors
Grinders	Hoists
Diggers	

**Greater Safety, Less Fatigue
to the Operator, Less Air Consumption
and Lower Performance Cost . . .**

THE I-R Pott Impact Wrench is something entirely new in pneumatic tools, and a development long needed.

It features an impact operation which is so far superior to other nut running methods, both applying or removing, that no shop performing such work can afford to be without the tool.

Its action is 85% smoother, enabling operators to work in any position with far greater safety and less fatigue. It is less than half the weight of other wrenches, and works faster and better with only half the air consumption. It eliminates the necessity of hammering caps and nuts for loosening, and easily removes frozen nuts that no other wrench can handle.

All details are available in a new bulletin. Send for a copy; it will interest you mightily.

Birmingham
Boston
Buffalo
Butte
Chicago
Cleveland
Dallas
Denver
Detroit

Duluth
El Paso
Houston
Knoxville
Los Angeles
Mexico
Newark
New York
Philadelphia

Picher
Pittsburgh
Salt Lake City
San Francisco
Scranton
Seattle
St. Louis
Tulsa
Washington

Ingersoll-Rand

11 Broadway, New York City

Compressed Air Magazine

A Monthly Publication
Devoted to the Many
Fields of Endeavor in
which Compressed Air
Serves Useful Purposes

FOUNDED 1896

SEPTEMBER, 1935

Volume 40



Number 9

EDITORIAL CONTENTS

G. W. MORRISON
President

R. A. LUNDELL
Vice-President

F. E. KUTZ
Secretary-Treasurer

J. F. KENNEY
Business Manager

J. W. YOUNG
Advertising Manager

Developing the Mighty Columbia—C. H. Vivian.....	4815
Mining Sulphur in Louisiana—R. G. Skerrett.....	4822
Heavy Road Job Finished.....	4827
Thirty Years of Canadian Mining—Kirkland Lake, Part II—R. C. Rowe.....	4829
Deception Pass Bridge.....	4834
Compressed Air Aids Manufacture of Machine Tools—Fred B. Jacobs.....	4835
Editorials—A Man Who Persevered—The Engineer's Place.....	4837
This and That.....	4838
Industrial Notes	4839

ADVERTISING INDEX

C. H. VIVIAN
Editor
A. M. HOFFMANN
Assistant Editor

European Correspondent
LINWOOD H. GEYER
144 Leadenhall Street
LONDON, E. C. 4

Canadian Correspondent
F. A. McLEAN
620 Cathcart Street
MONTREAL

Business, Editorial and Publication
Offices
PHILLIPSBURG, N. J.

Advertising Office
11 Broadway
NEW YORK CITY

American Brass Company, The.....	23
Austin-Western Road Machinery Co., The.....	17
Bethlehem Steel Company.....	7
Bucyrus-Erie Company	11-24
Combustion Engineering Co., Inc.....	3
Coppus Engineering Corporation, The.....	8
Dayton Rubber Mfg. Co., The.....	Back Cover
Direct Separator Co., Inc., The.....	11
General Electric Company	18
Goodrich Company, The B. F.....	16
Goodyear Tire and Rubber Co., Inc., The.....	13
Hercules Powder Company, Inc.....	4
Ingersoll-Rand Company	5-10-14-19-22
Jarecki Manufacturing Co.	11
New Jersey Meter Co.....	24
Norton Company	12
Owens-Illinois Glass Company.....	15
Socony-Vacuum Oil Co., Inc.....	Insert between 10-11
Texas Company, The.....	20-21
Timken Roller Bearing Co., The.....	9
Waukesha Motor Co.	Insert between 16-17
Westinghouse Electric & Mfg. Co.....	6

Copyright, 1935, by Compressed Air Magazine Company. Save in special cases, permission to reprint articles, with proper credit, will be granted upon request to the editor.

Annual subscription rate: Domestic, \$3.00; foreign, \$3.50. Single copies, 35 cents.

Manuscripts intended for editorial consideration should be accompanied by return postage.



COLUMBIA BASIN PROJECT AT A GLANCE

An artist's representation of the area under improvement, looking southward down the Pacific Coast. In the central foreground are Grand Coulee Dam, power house, and pumping plant. Above them is the Grand Coulee, an erosional gash which will be dammed at two points to create a reservoir into which Columbia River

will be lifted. Canals will distribute the water from this reservoir to 1,200,000 acres of land in what is known as the Big Bend section of eastern Washington. The site of Bonneville Dam is farther down the Columbia and a little to the left of Portland. Grand Coulee Dam will be 90 miles west of Spokane.

Developing the Mighty Columbia

C. H. Vivian

AT TWO points on the Columbia River the Federal Government is constructing dams of large size. Bonneville Dam, located 42 miles east of and upstream from Portland, Ore., is being built under the direction of the Corps of Engineers, U. S. Army, at an estimated cost of \$31,000,000. Farther upstream, about 90 miles west of Spokane, Wash., the U. S. Bureau of Reclamation is in

charge of the erection of Grand Coulee Dam, a project which will be carried out in two stages. The current program will cost more than \$63,000,000. The accompanying article presents general information concerning the Columbia River and its power and irrigation possibilities. In our October issue accounts will be given of the construction work now underway at the two dam sites.

THE building of Boulder Dam has directed the attention of the country to the water resources of the arid West in compelling fashion. The great engineering drama which has held the stage in Black Canyon since 1931 has gripped the interest and imagination of thousands of persons who have never seen the vast expanse of territory that lies between the Mississippi River and the Pacific Coast. For the first

time, a great many people who live in the favored belts where moisture is plentiful enough to insure ample crops have had brought home to them the realization that in many parts of the West water must be captured from streams and led to points of use. Water is, indeed, their most precious and most vital resource. Without it, millions upon millions of acres constitute little more than a parched desert; but with

it they blossom forth with foodstuffs for man and beast and support thriving cities.

The primary value of water, then, is for irrigation and domestic consumption. Its secondary value is for the generation of electric power. These two uses must oftentimes be dovetailed in order to make a water-development project economically feasible. Boulder Dam, for example, was conceived as an instrument of irrigation

and flood control more than 30 years ago, but the stupendous cost involved deterred commencement of the undertaking until the element of power generation was added to it. We shall see that Grand Coulee Dam on the Columbia River is in the same category. The point stressed here is that the first and most important purpose of storing and diverting water in the West is to provide sustenance for population, while the production of electricity is a more or less incidental function which sometimes is essential to the successful operation of irrigation schemes.

While Boulder Dam has served better to acquaint the nation at large with the water problems of the West, it has also inadvertently given rise to some mistaken impressions. The hugeness of Boulder Dam and the vagaries of the river which it holds back have been emphasized to such extent that the average person who depends upon newsreels, newspapers, and magazines for his information has gained the idea that the Colorado is the most mighty of the western streams. It is, in truth, a great river, and probably the most temperamental one in the country, but in sheer volume of water carried, and in potential power, the Columbia exceeds it by a wide margin. Authorities who have investigated the Columbia proclaim it is "second to none in the United States" with respect to its possibilities for the development of power.

There is some warrant for believing that it is perhaps the greatest river in the world from the power standpoint. By way of comparison, it may be stated that the total potential horsepower of the Tennessee River has been set at 4,000,000, while that of the Columbia is estimated at 21,000,000. The full import of the Columbia's latent power becomes apparent if we consider that it amounts to about one-third the total installed generating capacity of the country, both steam and hydraulic.

Dr. Elwood Mead, Commissioner of the Bureau of Reclamation, has stated that "the Columbia is the greatest river of the arid region, and almost equal to all the others put together." Including its tributaries, of which the Snake River is the most important, the Columbia drains an area of 259,000 square miles, or roughly the equivalent of the combined areas of New York, Pennsylvania, Ohio, Virginia, West Virginia, New Jersey, Delaware, Kentucky, and Maryland. The average annual run-off is 146,000,000 acre-feet, which corresponds to a rainfall of $12\frac{3}{4}$ inches deep over the entire drainage basin. This is approximately nine times the flow of the Colorado River at Boulder Dam.

The Columbia proper is about 1,210 miles long. It rises in Columbia Lake, in British Columbia, at an elevation of 2,650 feet. Its various tributaries reach into Washington, Oregon, Idaho, Montana, and

Wyoming. Its value for both irrigation and power lies in its sustained large flow throughout the year, thanks to the glaciers that feed its headwaters. Its appreciable fall is also an important contributory factor as regards its power potentialities. From the Canadian boundary to its confluence with the Snake, it drops 1,000 feet. In the course of its journey to the sea, it cuts through both the Cascade and Coast ranges. Geological research reveals that the stream bed in the lower stretches of the river was once from 1,000 to 3,000 feet below its present level. As the land subsided, the river filled in its old channel. There is virtually no flood problem on the Columbia. It flows between rock walls which are sufficiently high at all points to keep it in its course. Contrary to the Colorado, the Columbia carries only a small amount of silt.

The master of a Yankee sailing vessel, Capt. Robert Gray of Boston, entered the mouth of the river in 1792. The stream had previously been known as the Oregon, but he rechristened it the Columbia, after his ship. The new name soon supplanted the older one. The first information of value concerning the river that filtered back to the colonies resulted from the explorations in 1803 and 1804 of Meriwether Lewis and William Clark, who were dispatched on their historic expedition by President Thomas Jefferson. Upon their

DRY FALLS OF THE GRAND COULEE

This horseshoe-shaped precipice is five miles long and 400 feet high. It is at the lower end of the Grand Coulee, great erosional gash that marks the course which the ancient Columbia River followed during a period when a glacial ice dam diverted it from

its established channel. Geologists estimate that at one time there flowed over this bluff forty times the volume of water that now passes over Niagara Falls. When the ice barrier receded, the Columbia resumed its older course.





AS BONNEVILLE DAM WILL LOOK

A preliminary architectural study showing the projected landscape and general development. The gate-controlled spillway dam is on the left and the power house and lock are at the right. Across Bradford Island will run a connecting levee. Fish ladders are also shown there. Bonneville Dam will rise 170 feet above the lowest foundation and will create a maximum operating head of 67 feet at the turbines.

investigations, the United States primarily based its claim to the territory now embraced by the states of Washington and Oregon.

In some minds there is an impression that the movement to utilize the waters of the Columbia is a recent one, but this is not true. It has been under consideration for many years, but it was not until the country became attuned to spending vast sums for reclamation and power developments that the way was cleared for the inauguration of the current projects. Two governmental agencies have been concerned with the investigations. The Army Engineers have considered the Columbia chiefly from the standpoint of improving and extending navigation. The Bureau of Reclamation has been primarily interested in diverting some of its plentiful flow to neighboring arid lands. State and local organizations, particularly in Washington, have also had important parts in the movement. Probably the first man to give serious thought to large-scale development was Isaac Stevens, first governor of the Territory of Washington. In 1853 he wrote to one of his lieutenants: "I suggest that you examine the Great Grand Coulee."

The possibilities of irrigating the area in eastern Washington which is embraced in the Grand Coulee Dam scheme were examined by the Bureau of Reclamation as early as 1904. At that time it was believed that water could be put on this land by gravity, and surveys were made for canals which were designed to take off at considerably higher levels from the Columbia, Spokane, and Palouse rivers. Investigation revealed that storage dams would have to be built to provide sufficient water, thereby running the cost of the enterprise beyond what was then considered the economic limit and also re-

quiring the consent of the states of Idaho and Montana because some of the impounding structures would have been located within their borders. Further investigations were made by the Bureau of Reclamation in 1914 and 1915. The Columbia Basin Commission of the State of Washington published a report in 1920, based on field work done in 1919. The report was reviewed during the same year by a board of engineers of the Bureau of Reclamation. This plan contemplated

building at the Grand Coulee site a dam 180 feet above low water and pumping the storage to irrigable lands. In 1921 the State of Washington diamond drilled the dam site and conducted further inquiries. A board of engineers drawn from the Federal Government and from the states of Washington, Idaho, and Montana in 1923 made a report to the Federal Power Commission in 1923 that characterized the prosecution of the project at the Grand Coulee the most important item in connection with the utilization of the Columbia River above the mouth of the Snake River. This scheme, which came to be known as the Columbia River Project, was further investigated by the Bureau of Reclamation in 1923 and 1924, and a report made for the use of the Committee on Irrigation and Reclamation of the United States Senate. This report was reviewed and amended in 1924 by a board of engineers of the Bureau of Reclamation, and in the same year a group of engineers and economists was appointed by the Columbia Basin Commission of the Department of the Interior to make a further study of the report and also to conduct independent investigations. Upon receiving the report, in 1929, the commission concluded that the time had not yet arrived when local and national interests justified going ahead with the project. Studies of the water-supply and power-development problems of the Columbia Basin were continued from 1926 to 1930 by the U. S. Geological Survey with the collaboration of the State of Washington. A comprehensive investigation of the Columbia and its tributaries above the mouth of the Snake River was made from



A CONCEPTION OF GRAND COULEE DAM

A retouched aerial photograph on which the dam has been accurately located by a Bureau of Reclamation artist. In its finished state, this wedge of concrete will be so massive as almost to dwarf any previous similar structure. It will be 4,300 feet long, more than 500 feet high, and will contain more than three times as much concrete as Boulder Dam. The power generating units will be the largest recorded, and their output will exceed that of any existing plant.



PROGRESS AT GRAND COULEE

Before the large-scale program got underway at Grand Coulee, a relatively small contract was let for the excavation of 1,000,000 cubic yards at one of the dam abutments. The picture at the top shows this comparatively minor scar. At the left edge is the spoil dump. The other picture shows, by contrast, the feverish activity which followed later and which is now at its height. It was taken while the huge cofferdam was under construction. On the hillside in the background may be seen the escarpment on the cliff which comprised the earlier contract.

1928 to 1931 by the Corps of Engineers of the War Department. In addition to the army personnel, civilian specialists were employed to inquire into all phases of navigation, irrigation, flood control, and power development. A report tendered in 1931 by Major John S. Butler, district engineer in charge of the work, contained a wealth of general and engineering data, and these were made the basis for a study of the proposed irrigation project. Cost estimates were submitted on nine distinct plans for putting water on all or a part of the irrigable acreage adjacent to the Grand Coulee dam site. The Butler report was reviewed and approved by the Bureau of Reclamation, and the final plans for the Columbia Basin Project were based largely upon it.

From the foregoing résumé, which is devoid of details, it will be seen that the development of the Columbia River has been long and carefully considered. The Bureau of Reclamation alone expended more than \$350,000 for preliminary studies,

and sizable sums were also spent by the War Department and by the states of Washington and Oregon. All told, probably somewhere near \$1,000,000 has gone into the investigations. Many prominent engineers were retained at one time or another to make examinations or review reports. Among these may be mentioned Gen. George W. Goethals, builder of the Panama Canal, who prepared a report in 1921 at the request of the State of Washington. Without exception, all investigators have favored the systematic development of the Columbia's water resources. Presidents and cabinet members of all recent administrations have approved the movement, but it was not until the depression brought forth the expenditure of great sums for public works that definite steps were taken to put projects under construction.

The War Department report just referred to recommended the construction of ten dams in all, of which the one at Grand Coulee was to be the farthest upstream. The farthest downstream location was at

Warrendale, at the head of the tidal flow. The Bonneville Dam is being erected approximately at that point, being slightly upstream from it. Of the proposed intermediate dams, one at Rock Island Rapids, in Washington, has already been constructed as a private enterprise by the Puget Sound Power & Light Company. The cost of that development is reported to have been about \$25,000,000.

The Columbia Basin Project, of which Grand Coulee Dam is the key structure, has for its ultimate purpose the irrigation of 1,200,000 acres of land in what is known as the Big Bend section of eastern Washington. As this land lies approximately 630 feet above the present river level, the plan involves the construction of a high dam to raise the surface of the water 350 feet and lifting that water the remaining distance with power generated there. As originally instituted, the current program called for the building of a low dam (297 feet) and a permanent cofferdam at the downstream base, both of which would eventually have



WHERE THE COLUMBIA FLOWS

A general location map showing the Columbia River and its tributaries and the sites of the two dams under construction. The watershed is indicated by the light shaded area. It aggregates 259,000 square miles. The Columbia proper is 1,210 miles long and carries more water than any stream in the country except the Mississippi.

been incorporated in the higher structure. On June 7 of this year a change order was issued which altered the shape of the structure and provided for the construction up to a height of 177 feet of a complete foundation for the ultimate high dam. As the irrigation phases of the project cannot be put into operation until the high dam is in place, and as the foundation now underway will serve no useful purpose except regulation of the river flow, it is assumed that the completion of the structure will not be long delayed.

The initiation of this and other reclamation proposals in the Northwest came about as a result of changing economic conditions. Spokane sprang up and grew to a city by virtue of the wealth that poured forth from lumbering activities, from the Coeur d'Alene mines, and from the growing of wheat on semi-arid land. Seattle and Tacoma were nourished in municipal growth by exploitation of the timber and mineral resources, by the Alaskan trade, and by local farming. Gradually, however, the timber was cut off, the mines grew less productive, wheat-raising became a precarious venture. The

slack was taken up by growing fruit on irrigated tracts. Orchard products attained a steadily increasing importance in the commerce of the section, both domestic and export. It is said that there is not now a city of 100,000 persons in the world where one cannot obtain an apple grown on irrigated Washington land. The Yakima and Wenatchee Valleys are especially famous for this product.

As this changing trend manifested itself, it became more and more apparent to the residents of Washington that the future prosperity of the state was inseparably linked with the development of its water resources. At first Seattle and Tacoma believed that they were too remote from the Columbia to be much concerned about its development and considered it a matter of primary interest to Spokane. This attitude gradually changed, however, and in recent years there has been a state-wide unified endeavor to set in motion a program of construction looking towards making the waters of that great stream available for irrigation and power generation.

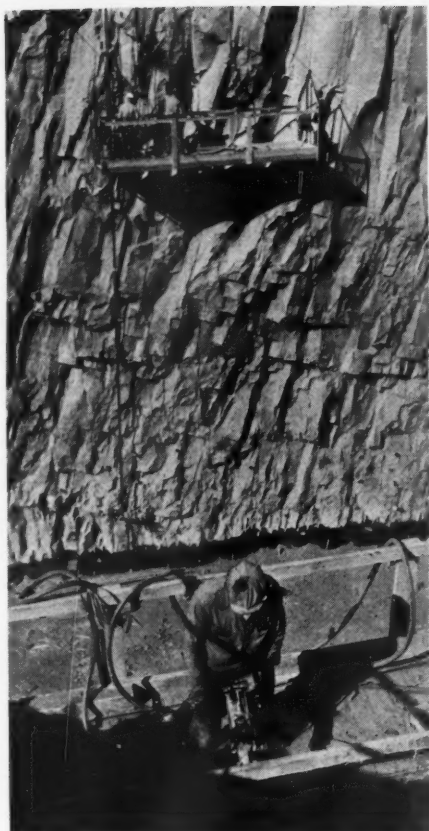
In order to justify the advancement of

Federal funds for such purposes, it is necessary to show that the works to be built will be of national rather than of purely local benefit. It is sometimes difficult for people in the Middle West and the East to see that the spending of money in the arid West will help them. In the case of the Columbia Basin Project, extensive investigations were made to show how it would affect the country at large. The findings were such as to cause no misgivings about the undertaking by other sections of the nation. They showed, for example, that the colonization of this land will create vast new markets for automobiles, radios, clothes, and other products of the East. Lest farmers of the Midwest be concerned about competition with them and possible overflowing of their markets, it was revealed that practically no corn is grown in the Northwest. It is shipped in, and it seems reasonable to assume that much more of it will be required by the greater population which this project will help support. As evidence of the influence which settlement of the Columbia Basin may be expected to have on the promotion of trade with other areas, it may be cited that during a normal year something like 70,000 carloads of material are shipped into the nearby Wenatchee and Yakima districts.

The land which is to be put under cultivation is highly fertile. Most of it is privately owned. It will be reclaimed land in the strict sense of the word, for efforts were made to grow wheat on it years ago, but the precipitation—normally less than 10 inches a year—was insufficient for the purpose. As a result the area is dotted with abandoned farms and towns. The soil and climate are similar to those of the Yakima Valley, but Columbia Basin has a two weeks longer growing season. It is admirably adapted to the growing of apples, pears, berries, potatoes and other vegetables, grapes, alfalfa, and sugar beets, and these would no doubt be the principal crops.

Preliminary plans for the ultimate Columbia Basin Project as worked out by the Bureau of Reclamation call for a total investment of \$404,633,000 to put the entire project in operation. This is made up of \$113,676,000 for the high dam, \$67,425,000 for the power plant, \$15,000,000 for interest during their construction, and \$208,532,000 for the irrigation development. The total cost is slightly more than was expended for the Panama Canal.

In drawing up the plan, it was contemplated that the irrigation development of the 1,200,000 acres would not start until the dam was completed and would take place gradually—the suggested rate being about 20,000 acres a year. Based on the current rate of increase in the use of electric power in the region and the predictable trend for the future, it was estimated that the entire output at the dam available for sale would be absorbed in a period of fifteen years and that the profits from that source would contribute to the cost of the irrigation development. The figures



IN BARGE LOCK

A lock 76x360 feet is included in the Bonneville project. This view shows drillers hewing the excavation from solid rock. The man in the foreground is standing on staging swung from above by ropes like the one on the opposite wall.

arrived at indicated that the sale of power would be sufficient to repay the cost of the dam and power plant with 4 per cent annual interest in 50 years; provide for operation, maintenance, and depreciation of the dam and power plant; and also provide a surplus of approximately \$144,000,000 which would be available for repayment of the cost of irrigation development and other purposes. Under this plan, it was proposed to liquidate half of the \$165-per-acre construction cost with this surplus revenue. The remainder would be borne by the land owners under a schedule calling for \$2 per acre beginning four years after settlement and continuing for four years, and then \$2.50 per acre for 32 years. In addition, it was computed that land holders would have to pay either \$2.59 or \$3.19 per acre per year for irrigation benefits, depending upon whether or not a depreciation reserve were provided. Total indicated payments per acre, therefore, would be either \$4.59 or \$5.19 per year for four years and either \$5.09 or \$5.69 per year for 32 years thereafter.

The high dam will rise more than 500 feet above the lowest foundation, will be 4,300 feet long, and will contain approximately 10,500,000 cubic yards of concrete (about $3\frac{1}{4}$ times the quantity used in Boulder Dam). It will be a straight gravity-type

structure, 455 feet thick at the base. It will have a spillway section 1,650 feet long and capable of discharging 1,000,000 second-feet of water under a head of 30 feet. The maximum recorded flood at this point was 725,000 second-feet in 1894. It will form a lake extending 151 miles to the Canadian border and having a surface area of 120 square miles. Just back of the dam the surface of the river will be raised 350 feet above low-water level. In order to secure the maximum amount of firm, or continuous, power, the reservoir will be drawn down 80 feet during periods of low flow in the river. This will release, in all, more than 5,000,000 acre-feet of storage water and will have the effect of increasing the firm power output of all dams which may subsequently be built between Grand Coulee and the mouth of the Snake River by 100 per cent, and of all those below the Snake, including Bonneville, by about 50 per cent.

The flow of the Columbia at the dam site ranges from 20,800 to 500,000 second-feet during normal years and averages 106,000 second-feet. This is equivalent to an annual run-off of 77,400,000 acre-feet (that of the Colorado River is about 16,000,000 acre-feet). In connection with the irrigation project, it is significant to note that the Columbia's maximum flow comes at the height of the growing season, when the demand for irrigating water is greatest. It is computed that this flow, augmented at times of need by the 5,000,000 acre-feet of storage, will be sufficient to maintain a continuous power output of 920,000 kw. When the irrigation project is fully developed, the water which it will require will reduce the flow past the dam and decrease the continuous power output to 800,000 kw. As now planned, the power plant will have an installed capacity of 1,890,000 kw., consisting of eighteen units of 105,000-kw. capacity each, nine on each side of the river. These units will be 22 per cent larger than those being installed at Boulder Dam, which are now the largest hydro-electric power units in the world.

Various authorities, including Gen. Hugh L. Cooper, builder of hydro-electric plants in different parts of the world of more than 2,000,000-hp. aggregate capacity, have expressed the opinion that this site offers possibilities for generating power at the lowest cost obtainable in the United States. The consensus of estimates is that the firm, or continuous, power can be produced for about 1.2 mills per kilowatt-hour at the switchboard. In compiling the prospective financial returns from the venture, it was considered that a price of 2.25 mills would be sufficiently attractive to induce power companies of the region to buy power from the Government to meet future needs, instead of constructing additional private plants. Figures show that the power consumption in the section concerned has been growing at the rate of about 9.5 per cent per year, a figure which formed the basis for the estimate that the power produced at

Grand Coulee will all be absorbed within fifteen years after the plant goes into operation. It is contemplated that this power will be transmitted as far west as Seattle, 165 miles away by air line, and to various parts of eastern Washington and northern Idaho. During all of the pre-depression considerations of the project it was expected that no construction would begin until there had been signed power contracts which would put the scheme on a liquidating basis—a procedure which was followed in the case of Boulder Dam and which has been a fundamental principle of all Bureau of Reclamation projects. However, to put men to work without delay, it was decided to go ahead under the PWA program.

The physical conditions on account of which this particular site was selected are the result of one of the most interesting geological phenomena to be found anywhere. Untold centuries ago, a glacier which advanced from the north thrust itself across the canyon of the Columbia, which was then flowing in a granite and basalt gorge 1,500 feet deep. This mass of mobile ice blocked the gorge, just as the wedge of concrete soon to rise there will block it again. But the ice barrier was higher than the man-made one will be. It raised the surface of the water 1,500 feet and caused the river to change its course, cutting a new channel in a southerly direction. For some thousands of years it



DRILLING UNDERWATER

This barge-mounted X-71 wagon drill performed many essential drilling tasks at Grand Coulee before the cofferdam could be constructed to bare the river bottom.

continued in its new bed, cutting a gorge 50 miles long, as much as 900 feet deep, and up to five miles wide. This erosional structure is known as the Grand Coulee. At its lower end is a sheer cliff that offers evidence of a former magnificent waterfall. Now dry, it stands 400 feet high and is five miles long. At one time, it is known, the Columbia—fed by glaciers that capped virtually all the land to the north—was a far mightier stream than at present, and it is estimated that the flow over the falls was about 40 times the present volume at Niagara. When the glacier receded, the river returned to its old circuitous course, leaving the Grand Coulee, a hanging valley, running off at an angle.

This coulee will serve as a reservoir for the storage of water to be used for irrigation. Dikes to be constructed at two points will form a basin 23 miles long and having a capacity of 1,050,000 acre-feet. By means of a 9-mile main canal and smaller distributaries, it will be possible to place water directly on 981,000 acres by gravity flow. By pumping to heights not to exceed 100 feet, the remaining 219,000 acres can be watered. As previously stated, all this water will have to be lifted into the Grand Coulee from the reservoir formed by damming the river. It is planned to install a pumping plant that will be capable of moving 16,000 second-feet of water a distance of 1.7 miles and raising it a vertical height of 280 to 360 feet, depending upon the level of the lower reservoir. The plant will contain twenty units of unprecedented size. Each will be direct connected to a 33,000-hp. motor and will be capable of handling 3,600,000 gpm. against a head of 370 feet. Surplus or seasonal power will be used to

operate these pumps; and, as previously stated, there will be plenty of this available by reason of the fact that the river flow is greatest during the summer when water is required for crops. The power demand for this intermittent service will be 525,000 kw. It will be furnished at a charge of \$1 per acre per year, which corresponds to about one-half mill per kilowatt-hour.

Bonneville Dam has for its purposes the generation of power and the improvement of navigation. The Columbia River is now navigable to ocean-going vessels as far upstream as Vancouver, Wash., which is about 45 miles below the dam site. From Vancouver to Bonneville the average controlling depth of water is 8 feet. Bonneville Dam will produce an average depth of 30 feet from that point to The Dalles, 49 miles distant. With the dam in place, subsequent deepening of the channel between Vancouver and Bonneville would permit ocean-going ships to ply as far as The Dalles, 192 miles from the mouth of the river.

The work now underway at Bonneville is designated as Project No. 28 of the PWA. It provides for a gate-controlled spillway dam, a power house with two generating units of 43,000-kw. capacity each and positions for four others, and a barge lock 76 by 360 feet in dimensions. The dam will be a mass concrete, gravity-type structure. It will rise 170 feet above the lowest foundation, will be 1,250 feet long, and have a basal thickness of 180 feet. It will create a maximum operating head of 67 feet at the turbines. The amount of excavating required is estimated at 6,284,000 cubic yards, of which 1,967,000 cubic yards is rock. The project involves the relocation of two railroad lines, one on either side of the river,

and short sections of the Columbia River Highway to bring them above the high-water line. About 8.8 miles of new trackage will have to be laid. On the Oregon side of the river much of this reconstruction is taking place through an ancient landslide. Shifting of the ground has caused much trouble, and the driving of tunnels to drain off water from the interior of the mass is being resorted to.

At the site of Bonneville Dam, the Columbia River channel is divided by Bradford Island. The spillway section will occupy the north, or main, channel, and the powerhouse and navigation lock will be built across the south channel. The two sections will be linked by a levee across the island.

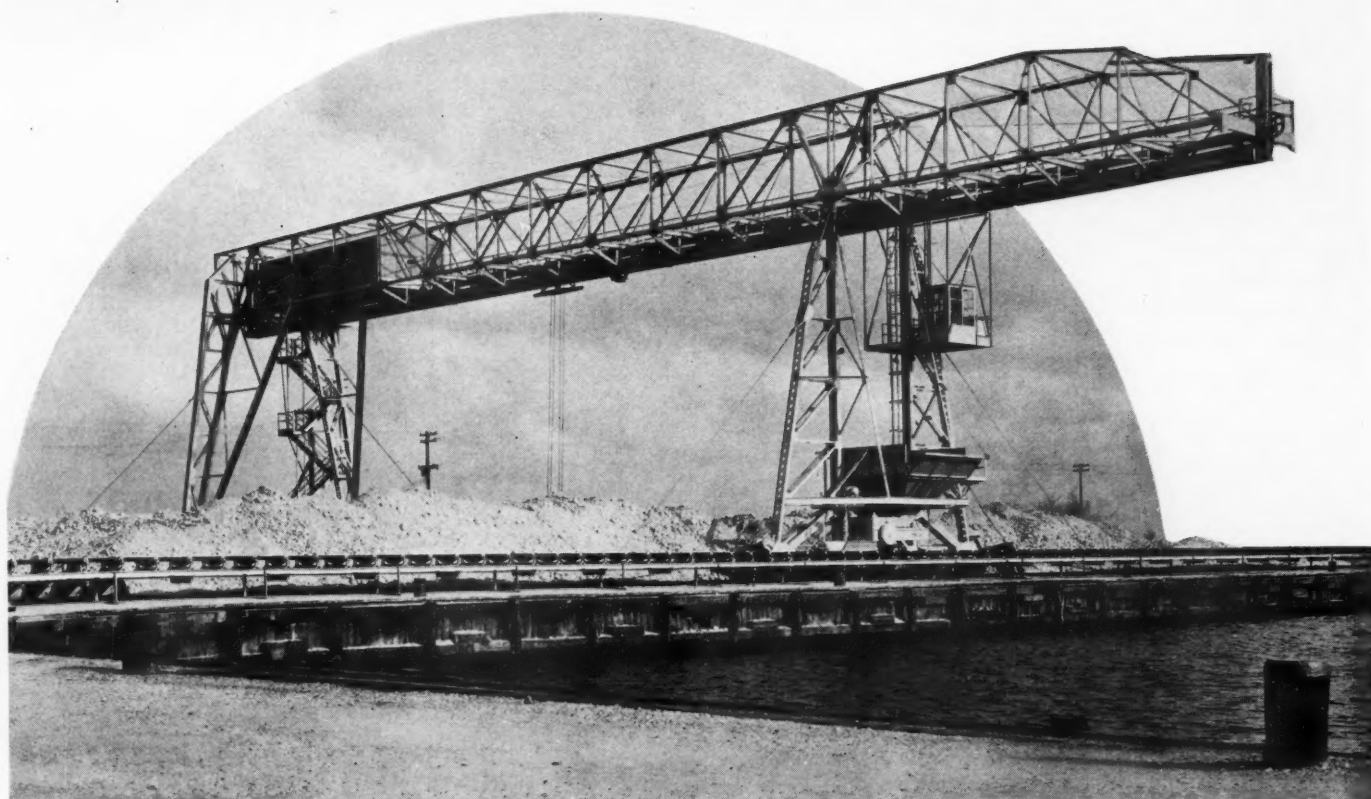
The location of Bonneville Dam, like that of Grand Coulee, was decided upon largely because of a geological manifestation of unusual proportions. As was mentioned before, the site is a little upstream from the Warrendale location, and was selected in preference to it because of the superior foundation conditions. These conditions came about through a gigantic rock slide which entered the stream from the Washington side. As the story of this displacement is reconstructed by Dr. E. T. Hodge, consulting geologist on the project, the river bed was then about 300 feet lower than at present, and was surmounted by steep cliffs on the northern shore. Saturation of the rock and soil, combined with undercutting, weakened the flanking structure to such a degree that it gave way under the impulse of some disturbance such as an earthquake or, perhaps, from being soaked by a prolonged rainfall. Whatever the immediate cause, a slide three miles long was precipitated into the river, forming a dam which raised the water surface 500 feet. It is known that this happened probably not more than 500 to 1,000 years ago, because of the state of preservation of trees found embedded in it. Further evidence that it was of comparatively recent occurrence is found in the fact that the account of it has been handed down from generation to generation of Indians. These native Americans termed it the "Bridge of the Gods," and believed that it was placed there by the gods to furnish a means of crossing the river. Eventually, the action of the river lowered the crest of the slide by 200 feet, and filled in the deep water behind it. The rock meanwhile became sufficiently consolidated as to form a firm foundation for the structure that is now rising there.

Initial work on the current construction operations was actually started at Boat Rock, about 3,000 feet upstream from Bonneville. The undertaking was drowned out by a 25-year cyclical rise of the river which brought unusually high water in June, 1934. With subsidence of the stream, borings disclosed that several millions of dollars could probably be saved by shifting the site to Bonneville, where superior foundation conditions prevailed. This was accordingly done.



A BONNEVILLE PIONEER

As is usual on construction jobs, rock drills were called into action early in the work. The "Jackhammer" operator in the foreground is drilling a foundation excavation for the installation of a hoist.



AT PORT SULPHUR

A canal 100 feet wide and 9 feet deep was dredged ten miles to connect the sulphur deposit with the Mississippi. At the river end the

Town of Port Sulphur was constructed. This picture shows the mechanical equipment at its dock for the handling of materials.

Mining Sulphur in Louisiana

R. G. Skerrett

SULPHUR mining in Louisiana is now in a stage of revival, after a quiescent period of about a decade, by reason of the comparatively recent tapping of new sources of supply in the cap rock of certain salt domes close to the Gulf Coast of that state.

It is still fresh in the minds of many of us how serious prospectively was our situation when our imports of Sicilian sulphur were cut off in the early period of the World War. For years we had depended mainly upon Italy to furnish us with sufficient quantities of that material to satisfy our numerous industrial demands. Then it was that we suddenly realized the treasure that nature had stored in the sulphur-bearing rock surmounting our southern salt domes.

The pages of this magazine have on occasions referred to these curious geological formations and to the supposed genesis of the sulphur from the anhydrite that rests just above the immeasurably vast bodies of rock salt. We shall therefore not repeat those details. About 50 salt domes have been discovered at different times in the coastal plain of both Texas and Louisiana;

but it is said that not more than one in every ten has indicated the presence of enough sulphur to warrant commercial exploitation.

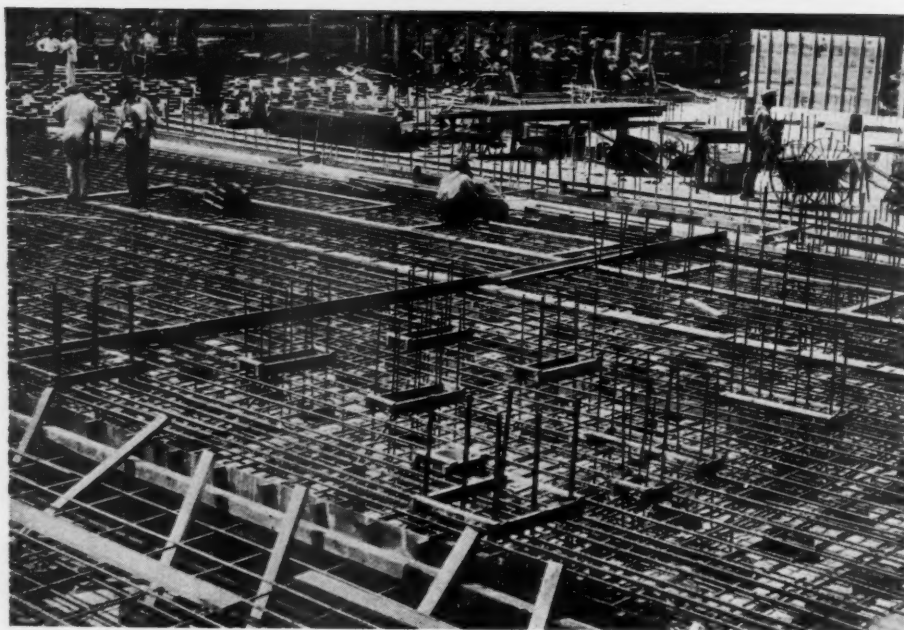
Nearly a century and a half ago, a white man hunting near the mid-length of Louisiana's coastal region came upon springs welling brine from what probably once was the rocky cap of a salt dome eroded in the course of ages. Even the Indians then living there were ignorant of their existence; and yet the hunter found widespread beds of ashes, several feet thick, intermixed with bits of pottery and other relics which indicated that long-forgotten aborigines had made a practice of evaporating the brine for their use.

It was not until 1865 that sulphur was discovered in Louisiana, so far as records show; and where the mineral was first recovered on a commercial scale the Town of Sulphur came into being. That deposit of pure sulphur, about 100 feet thick, was tapped by drillers in search of petroleum when their prospecting bits had penetrated rock that lay hundreds of feet beneath a bed of quicksand. Wide as was the interest

it aroused, yet three decades of discouraging work elapsed before the mineral could be mined, and then not by any conventional method.

Time and again it was found impossible to sink a shaft to the cap rock: the hydrostatic pressure set up by the surrounding water and quicksand inevitably crushed in the shaft lining. Ultimately, one was carried down; but the miners were speedily suffocated by the noxious gases that escaped from the formation. That disaster indicated that no man could work in the deadly atmosphere. It was at that discouraging stage that the problem appealed to the fertile-minded Herman Frasch, who up to then had been absorbed in research having to do with the drilling for and the refining of petroleum. Even that genius wrestled from 1891 to 1903 with the task before he evolved his unique process for mining the sulphur stored in the cap rock of the Gulf Coast salt domes.

One difficulty after another had to be disposed of to make his process, so simple in principle, a workable one. It was not enough to force superheated water into a



sulphur-bearing stratum to melt the imprisoned mineral so that it could be brought to the surface with the aid of the air lift: means had to be devised to keep the sulphur from cooling and crystallizing during its journey upward lest it clog the pipes and entail heavy losses. Besides, the liquified sulphur and the hot water at the lower end of the pipe in each well had to be separated so that they would not form an objectionable emulsion. Finally, the entire system had to be susceptible of such nice control from a central point above ground that it would meet the ever-changing conditions within the area tapped by each well.

Sulphur mining by the Frasch process started in 1903. Since then the system has remained fundamentally the same, but has been improved in details as experience has ripened and other engineering minds have discovered how greater efficiencies—incidentally economies—could be realized. Today, plants of this kind are complex in their get-up and imposing in their scope. Unquestionably, Herman Frasch gave us a key to nature's treasure house, and through that we have become self-sufficient in the matter of our domestic sulphur supply and the dominant figure in the world's sulphur market.

Compared with the immense quantities of coal and iron we produce, our output of sulphur is relatively modest, but its importance is not lessened by that fact. Five years ago we mined nearly 2,560,000 long tons; and in the same year we sold at home and abroad about 1,990,000 tons valued at approximately \$35,800,000. Production has been lower since then, but is now showing a definite upturn. Sulphur, as such, is used in connection with the preparation of heavy chemicals, fertilizers, and insecticides; the making of pulp and paper, explosives, dyes, coal-tar products, rubber, electrochemicals, and fine chemicals; and the manufacture of paints, varnishes, food-stuffs of many kinds, and numerous other commodities. Sulphuric acid, widely known as the "Old Horse of Chemistry" and largely made in this country from sulphur, is utilized in the following industries: fertilizer, petroleum refining, chemical, iron and steel, paint and pigment, explosives, rayon, cellulose, textile, etc. Indeed, sulphur and its derivatives serve us virtually in every department of modern life. Such being the case it is timely to tell what the Freeport Sulphur Company has latterly been doing in reviving Louisiana's prestige in the field of sulphur mining.

Once again the quest for oil has been instrumental in revealing a great deposit of

BUILDING UNDER DIFFICULTIES

The problem of providing stable foundations for buildings in the swampy marshland was solved by driving closely spaced piles, sawing their tops off to a common level, and then pouring reinforced concrete mats. These successive operations are shown from top to bottom in the pictures at the left.



BEGINNING A SULPHUR BLOCK

The pipes at the right are delivering molten sulphur to a storage area. As the mass is built up, the retaining side boards are carried progressively higher. Eventually an enormous brick of practically pure sulphur results.

sulphur far underground in an isolated coastal section of the Creole State. Back in the summer of 1929 the Humble Oil & Refining Company did exploratory drilling on a salt dome beneath Lake Grande Ecaille. In the course of that work sulphur water was brought to the surface from one well that reached a depth of 1,735 feet; and in the case of another traces of sulphur were found in the cap rock at elevation -1,520. Rock cores brought up subsequently indicated a richer sulphur content—enough, in fact, to prompt the Freeport Sulphur Company early in 1932 to obtain from the oil companies controlling the property the right to mine for that mineral.

Lake Grand Ecaille, it should be said, lies ten miles west of the Mississippi River, 45 miles by air line south of New Orleans, and within four miles of the Gulf of Mexico, with which it is connected by a small tidal waterway. It is in that immense low-lying expanse known as the Delta of the Mississippi. Much of the delta marshland is alluvial in its origin—earthy matter carried toward the coast from inland, as well as sand swept shoreward by the tides and the winds. On this insecure formation salt grasses alone have established themselves and have produced a fibrous mattress from a few inches to several feet thick. This vegetation floats on a stratum of ooze several feet in depth, and this in turn overlies a greasy and unstable clay. So much for the setting of an imposing industrial venture.

Prospecting by the Freeport Sulphur Company started in April of 1932, and a survey by means of the torsion balance made it possible quickly to determine the size, the depth, and the conformation of the dome, which was found to have an ex-

panses of 1,100 acres within its 2,000-foot contour. Eighteen exploratory wells were drilled and sampled, and the cores and washings indicated sulphur in quantities warranting commercial exploitation. Where cuttings were recovered, not cores, the water used for drilling as well as the cuttings were brought to the surface by air lift. Compressed air for this service was

transmitted through a half-inch line in the drill stem and at a pressure of 150 pounds. That method of sampling gave nearly 100 per cent recovery of the rock pierced, and permitted both rapid and exact examination.

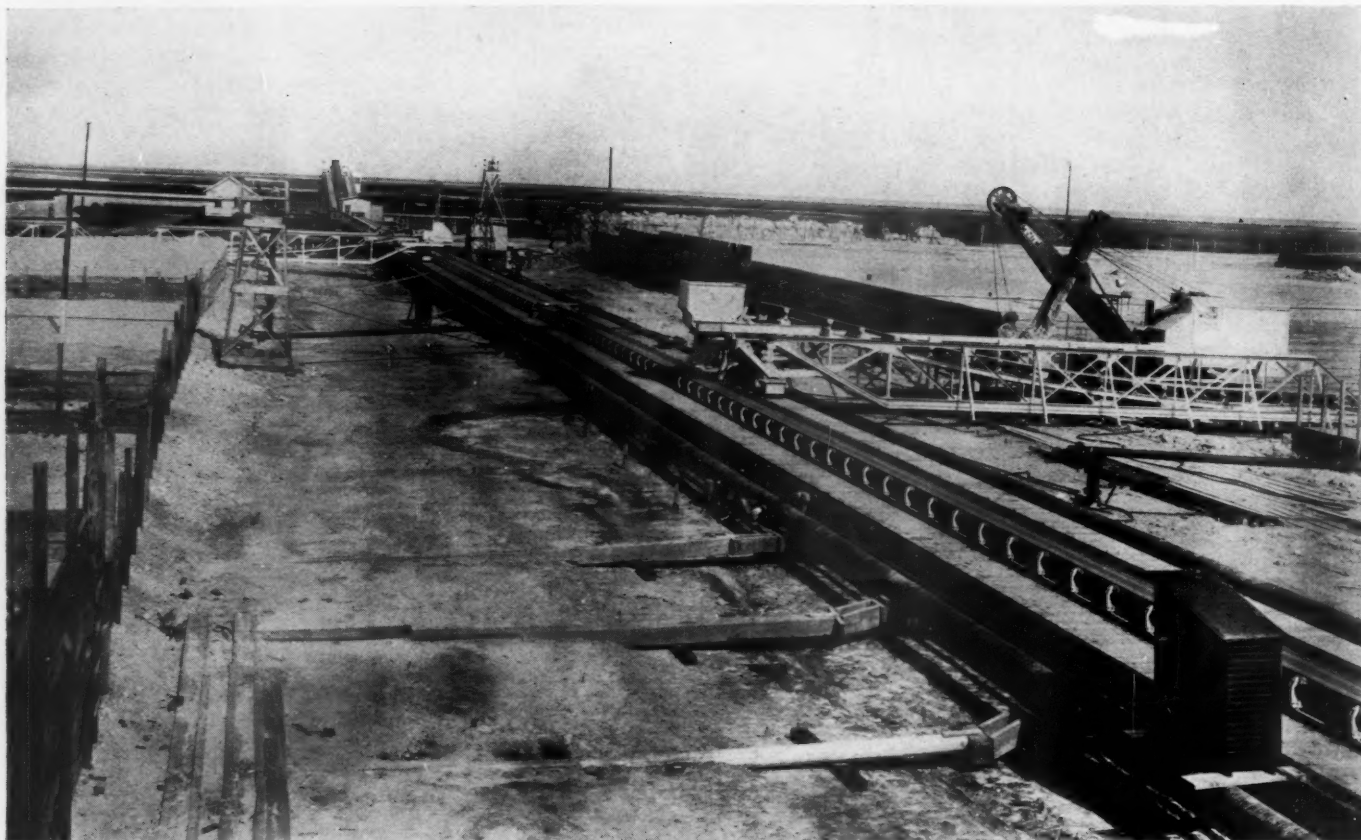
Profiting by the experience of the Humble Oil & Refining Company at Lake Grand Ecaille, where large timber mats for the support of drill rigs had to be abandoned owing to the unstable character of the soil, the engineers of the Freeport Sulphur Company placed their derricks and drill rigs on steel barges the hulls of which were rectangular in plan, had a beam of 36 feet, a length of 80 feet, and a depth of 6½ feet. Each was subdivided by lengthwise and crosswise bulkheads that formed a number of watertight compartments and stiffened the vessel to withstand the vibratory stresses set up by the rotary drilling rig. The two aftermost compartments were used to hold drilling mud, while those forward served as ballast tanks to maintain the craft on an even keel. The unusual feature of the hull was the way in which the half from the bow back to mid-length was modeled as two hulls separated by an open well 4 feet wide. This central passageway, much like the gap between two tines of a fork, made it easy to center a barge over a well site or to back her away from a casing that projected above the water.

Each vessel carried a 90-foot derrick and a 100-hp. draw-works oil engine. These were mounted on a superstructure 8 feet above the main deck, on which there was an additional 50-hp. oil engine that supplied power for the slush pump, the electric-lighting system, the rotary-drill rig,



POWER PLANT

Because subsidence usually follows removal of the sulphur from the ground, the permanent buildings were erected at a distance of 4,000 feet from the mining area. This view shows the power plant and associate buildings, with a section of the viaduct which carries pipe lines and railroad tracks.



STARTING TO MARKET

Sulphur for shipment is obtained by drilling and blasting the storage blocks. The material is delivered by feeder conveyors on to the main conveyor running between the stock piles and is carried by it to the dock for loading.

etc. Several airplane propellers, driven by motor-car gasoline engines, served as blowers to keep the mosquitos away. At each of the four corners of a barge was a tubular steel spud, 36 feet long. These were lowered to hold the craft in position while working at a well site. The barges could be moved rapidly from one point to another, and saved much time and money that otherwise would have been expended in shifting.

The practice was to dredge a canal 6 feet deep and 45 feet wide to a given well site, and then to widen it 70 feet for a distance of 175 feet to facilitate the movement of vessels bringing essential supplies and materials. Later, when mining succeeded exploratory work and a fill had been placed over the entire area, the derricks were erected where necessary on timber mats. At each location a section of casing, 80 feet long and 15½ inches in diameter, was driven down from the surface and served as a guide in drilling a 13¾-inch hole to the cap rock, where a 10-inch casing was set and cemented at an average depth of 1,250 feet. Following that, the cap rock—usually 250 feet thick and made up of limestone, calcite, gypsum, anhydrite, and sulphur with traces of pyrite, barite, and celestite—was drilled to the anhydrite underlying the sulphur-bearing calcite.

The several sections of a well casing contain two smaller concentric pipes. The innermost one carries compressed air into the

well; the succeeding annular space constitutes the air-lift passage through which the molten sulphur is brought to the surface; while the outlying still larger annular space carries superheated water down into the mine. The water is at a temperature of 350°F. and is delivered by booster pumps at a pressure of 250 pounds per square inch.

As sulphur mining by the Frasch process commonly causes subsidence of the dome structure, the Freeport Sulphur Company selected a site for its main power plant and associate buildings at a distance of 4,000 feet from the mining area; and the problem was to give them foundations that would stay put in that marshy setting. Numerous test piles were driven to ascertain how long they would have to be safely to carry their probable maximum loads. It was disclosed that no stratum existed near enough to the surface to give any real support; and in the end the friction between the piles and the enveloping mobile soil was depended upon for the necessary sustaining action.

The main buildings have an underpinning of piles averaging 75 feet long and spaced on 2-foot 8-inch centers. With the driving hammer resting on it, any one of them would sink by dead weight 45 feet through the upper stratum; but when forced to the prescribed depth, the piles were more firmly held by the soil. The tops were leveled off and embedded in a reinforced-concrete mat 2 feet 6 inches thick. The foundation walls, also of concrete, were tied to and rested on

this mat, thus forming a rectangular open box within which, at prescribed positions, were erected piers to support the overlying floor and plant equipment. In the case of the big power plant, the basement serves as a capacious tank for the storage of cold, fresh water. The permanent structures have steel frames, and are roofed and sided with asbestos materials. They are designed to withstand a wind with a velocity of 125 miles an hour.

To facilitate heavy construction work and plant operations, the company dredged a canal nearly 100 feet wide and 9 feet deep to serve as a traffic link between Lake Grand Ecaille and the Mississippi, ten miles eastward. At the river terminal an industrial community, Port Sulphur, was developed as a base for rail and water transportation to and from domestic and foreign points. It has been provided with a large pier and with ample loading and unloading machinery. In digging the canal, 2,000,000 cubic yards of material was excavated.

The areas about the plant and over the mine field have been built up with 3,000,000 cubic yards of soil—much of which had to be dredged from a depth of 40 to 50 feet. This work was done by the company's dredge, *The Chert*, which has as prime movers two Ingersoll-Rand oil engines of 300 and 350 hp., respectively. The craft has a Type 30 starting compressor and a Type 2-BJV centrifugal pump for salt-water service. The mining zone has been

filled to an elevation of from 4 to 8 feet, and the fill at the sulphur-storage area rises to an elevation of 12 feet to protect it from water when the gulf tides are at their storm height. The material for another fill of 500,000 cubic yards, at Port Sulphur, was obtained in excavating for the 50,000,000-gallon reservoir which serves there as a settling basin for the muddy water drawn from the Mississippi. This water is pumped by a pipe line paralleling the canal to the plant at Lake Grand Ecaille because it is very low in salt content, while the lake water is very briny and unfit for either boiler feed or sulphur mining.

For those services the river water is treated chemically—boiler water undergoing a hot-lime-soda treatment and mining water a hot-lime treatment. Exhaust steam from various prime movers first preheats it to a temperature of 218°F., after which high-pressure pumps take it and pass it through high-pressure heaters where the water is brought in direct contact with live steam at 120 pounds pressure, thus raising its temperature to about 350°F. At that stage booster pumps force it down into the sulphur-bearing stratum of the cap rock. All piping leading from the power plant to the wells and back to different points at the surface are heavily insulated to minimize heat dissipation.

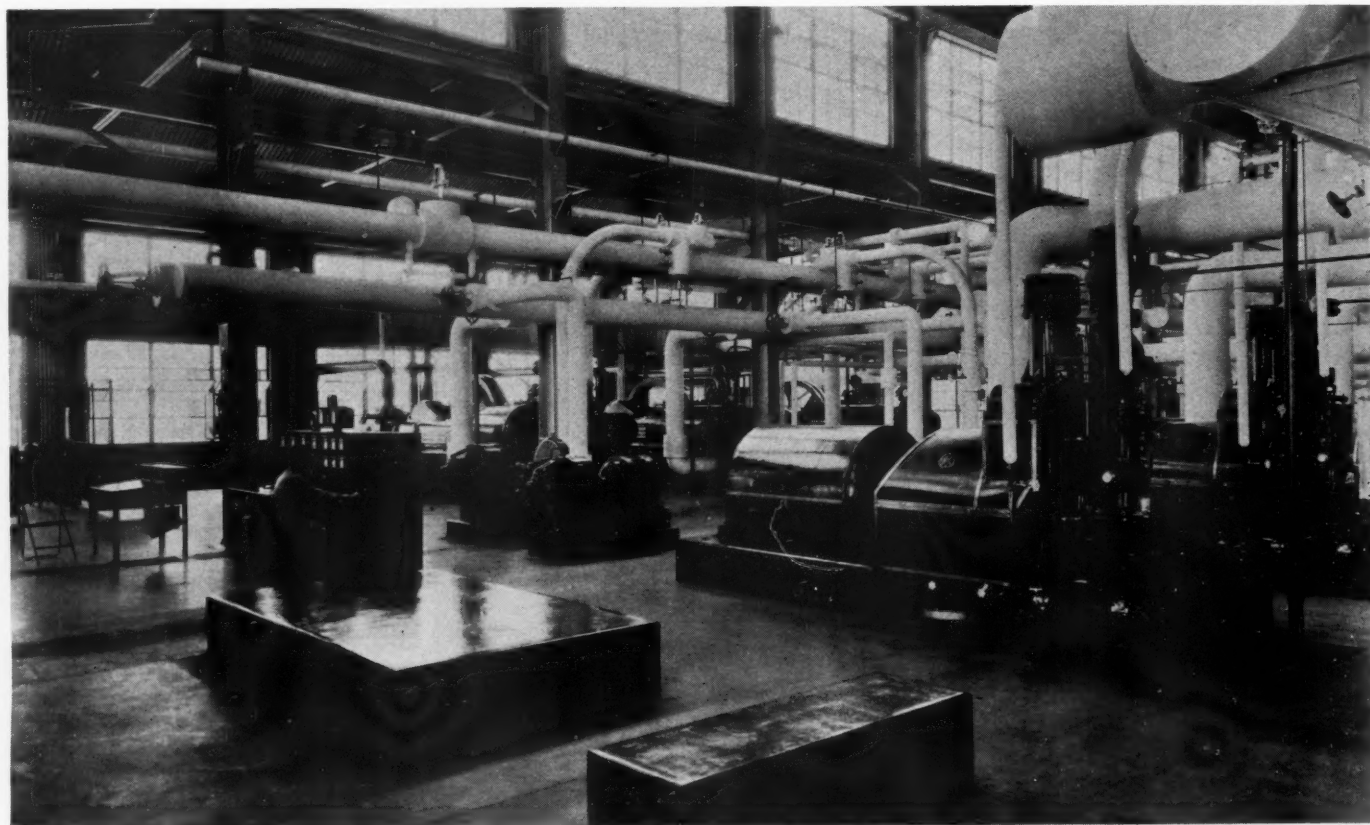
At Port Sulphur there is an electrically driven Type 20 vertical, duplex, single-stage compressor with a capacity of 170

cfm. that furnishes air in the reservoir pump station. In the big steam plant adjacent to the mine wells are six 860-hp. water-tube boilers designed to operate at twice their rating. They can burn oil, gas, or pulverized coal. For water service the plant is equipped with four Type 5-EV and one Type 3-BEV centrifugal pumps which are part of the booster system that delivers hot water to the sulphur wells. Two Type NFV centrifugal pumps distribute cooling water; and there are besides a Type NFV backwash pump and a Type 2-RVH-15 pump—the latter being used in the hot-process plant where the raw river water is treated for boiler feed and sulphur mining. Indispensable air for the Frasch process is supplied at 800 pounds pressure by three Ingersoll-Rand XPV compressors each of 750 cfm. capacity. Some of this air serves one purpose or another in the associate shops at the lake. In addition, a 185-cfm., 2-stage, air-cooled portable compressor and pneumatic chippers and calking hammers are employed in making alterations and in doing other essential jobs, while an air-driven No. 7 piston-type grinder does much useful work in the machine shop.

The economic use of fuel in sulphur mining is of major importance. The boiler plant has an operating efficiency of 80 per cent: the over-all efficiency of the entire plant is said to be as high as 77 per cent. Of the utilized heat from this fuel around 3 per cent is required for handling the liquid

sulphur in the pipe lines and at the surface stations, and less than 1 per cent is consumed in providing auxiliary power for the generators, pumps, compressors, etc. Thus, more than 96 per cent goes underground to melt the sulphur and to bring it to the surface. When running at maximum capacity, the plant can deliver to the mining area every 24 hours 2,800,000 gallons of water at a temperature of 350°F. and at a pressure of 250 pounds. Three-quarters of it goes underground: the remainder is boiler feed. A comparatively low hydrostatic pressure must be maintained in the sulphur-bearing formation, and to do this all the water must be withdrawn from the mines at points suitably remote from the wells. Before disposal, this waste is run through a treating unit to remove objectionable sulphide impurities.

After the molten sulphur reaches the surface it is discharged into great demountable, timber-walled vats in which it progressively cools and solidifies in mountainous blocks. When wanted for shipment, the mineral is drilled and blasted and loaded by an electric caterpillar shovel on to belt conveyors that carry it to barges at a dock about 400 feet away. From there it is transported to Port Sulphur, a village that has comfortable accommodations, recreational facilities, and other conveniences for the company personnel and families based there. Operating headquarters and a laboratory are also at that river station.



INTERIOR OF POWER HOUSE

Enormous quantities of hot water are required for melting the sulphur from its underground matrix and considerable volumes of high-pressure air are needed to raise it to the

surface, hence a power house of large size is provided. It is noteworthy for its high efficiency. At the far side of this engine room are shown three steam-driven Type 10 compressors.

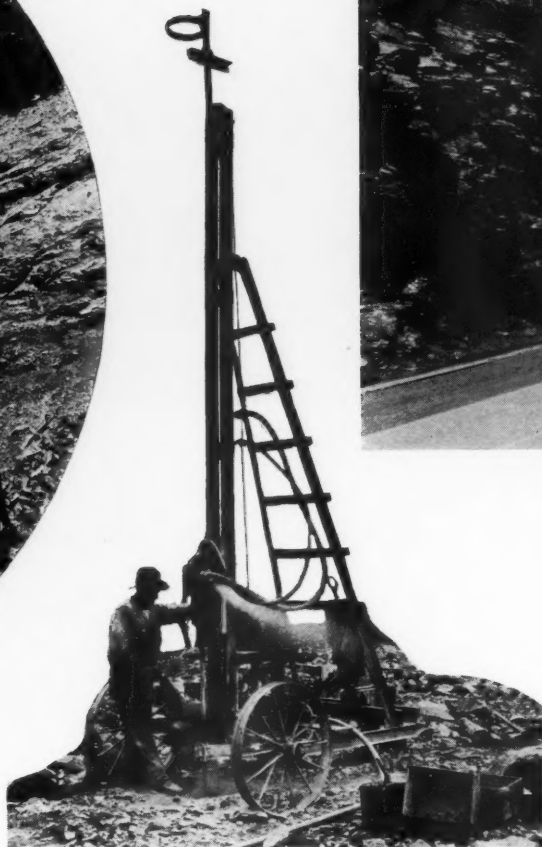


Heavy Road J

ON THIS page are construction views and finished scenes of a highway rebuilding project, on the Wilkes-Barre-Hazleton Turnpike in Pennsylvania, which is characterized by two cuts and one fill of spectacular proportions. The work, which was done by the W. Grant Raub Company of Red Lion, Pa., was described in detail in our October, 1934, issue.

In order to eliminate a sharp hairpin turn and to secure a better grade, approximately 260,000 cubic yards of rock was excavated from two cuts, aggregating 1,600 feet long, and all of it deposited in one gigantic fill 1,050 feet long, more than 300 feet thick at the base, and with a maximum height of 122 feet.

In carrying out this task, wagon drills once more proved their suitability for heavy rock work. For the greater part of the construction period, all primary drilling was handled by two X-71 drills. Towards the finish, a third machine of the same type was



Road Job Finished

tion views
ghway re-
kes-Barre-
nia, which
and one fill
The work,
rant Raub
described
issue.

rp hairpin
le, approx-
rock was
ating 1,600
ed in one
e than 300
maximum

agon drills
y for heavy
of the con-
rilling was
owards the
e type was

added. For fourteen months, these units worked from 21 to 23 hours daily. All drilling was done with "Jackbits," and compressed air was supplied by three 370-cfm., 2-stage, air-cooled portable compressors.

The upper end of the contract section as it looked at the start of work is shown at the upper left, while the cut which was made there appears in the circle. At its deepest point this cut was carried 115 feet below the former ground surface. At the upper right is the lower of the two cuts.

The pictures at the bottom indicate the proportions of the fill. At the left it is shown when it had progressed about half way across the valley it spans. On the right is a recent view of the upper portion of the completed fill, the base and ends being hidden by the foliage. Approximately 500,000 tons of rock are contained in it. Sections of the old road, which has in the meantime been abandoned, are to be seen in the foreground.



September, 1935

4828



Thirty Years of Canadian Mining

Kirkland Lake—Part 2

R. C. Rowe

III

Which is Mainly a Review

"And therefore today is thrilling
With a past day's late fulfilling."

ARTHUR O'SHAUGHNESSY.

GENERALLY speaking, after a mining camp has passed through the growing pains of early development, it settles down to the somewhat prosaic processes of coördination and expansion. Managements tighten up, and efficiencies are calculated in decimal points. Engineers and officials get down to routine, and strict utility and practicability replace the color and the romance of pioneering. This, with certain qualifications, was precisely the sequence of events at Kirkland Lake; but the camp has always reserved for itself, and for the delection of the world at large, certain qualities that have prevented its history subsequent to 1920 from being a monotonous recital of accomplishment.

During 1920, the output of the camp reached \$1,000,000 for the first time. In 1921, it was more than \$1,500,000, and in 1922 it exceeded \$2,100,000. It continued this progressive and orderly increase of from \$500,000 to \$750,000 per year until

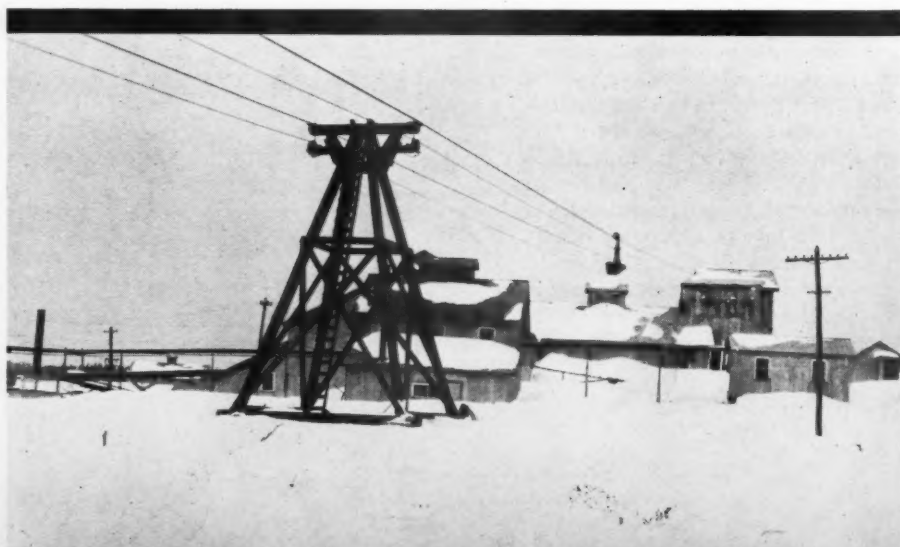
1924, when the total amounted to \$3,456,453. After that, production commenced to display acrobatic qualities, for in 1925 it climbed a cool \$2,000,000, a feat which it repeated in 1926 and proceeded to better in 1927 by jumping more than \$2,500,000 to \$9,703,843. By 1929 it attained \$14,089,233, and in 1930 the output reached \$3,000,000 more and was running neck and neck with Porcupine. In 1931 it passed the latter in the race for supremacy, a position it has held since with the exception of 1933 when the older camp had a slightly higher production.

At the back of this array, which chroni-

cles the growth of the camp, there are some facts which, as we have already said, prevent the later history of the camp from becoming a mere procession of figures, interesting as they are as an illustration of the wealth of the vein systems and of the efficiency of the mines themselves. In the first place, the structural geology of the area is somewhat complex, and was not easily understood. There is a rake to the ore shoots. It was this rake that started Dr. J. B. Tyrrell, managing director of Kirkland Lake Gold, on his brilliant piece of geologic reasoning whereby he predicted that certain of the Teck-Hughes ore bodies

AERIAL TRAMWAY

Although Ontario's topography is not so rugged as to require extensive use of overhead transportation of ore, there are places where it proves of advantage. This view was made at the Tough-Oakes property.





MACASSA MINE

This property, which lies directly west of Kirkland Lake Gold Mines, Limited, was originally staked in 1912, but little was

done with it for many years. Twenty-one years later it was put in production and a 200-ton mill built.

would rake into Kirkland Lake Gold ground at below the 2,000-foot level. He had the courage of his convictions, and his company had the courage to back his reasoning, with the result that shaft-sinking was carried on and the ore was found.

The westerly rake of the ore bodies at Kirkland Lake was responsible for the formation of a pretty theory which was to the effect that the ore-bearing zone of the district formed a wedge in its vertical section with its thin edge at the easterly end and its deep end to the west. The early behavior of the Tough-Oakes, and the rather doubtful results obtained during the youth of the Sylvanite, probably had a good deal to do with the birth of this theory, which exercised the imagination of a number of people at various times and which precluded any comfortable feeling of security for some while. It was a pretty theory; but it was most effectively punctured by the fact that both Sylvanite and Wright-Har-

greaves found ore on levels which were far below the theoretical vertical limits imposed thereby. In consequence, this interesting interpretation of structure was discarded; but it was one of the things that prevented the contemplation of Kirkland Lake from becoming too dull.

Another feature of the camp that always kept it from settling into a placid rut in the public mind was the fact that, like wine, it improved with age. As workings went lower, widths and values increased, and developments in this direction were so often spectacular that they eventually almost ceased to cause surprise. In the Lake Shore, for instance, widths exceeding 50 feet were encountered, and recoveries were well over an ounce of gold per ton for a long time. Even with the large capacities of latter days they have remained around $\frac{3}{4}$ ounce. At the Teck-Hughes recoveries for years were more than $\frac{3}{4}$ ounce per ton of ore treated, and for two years amounted

to nearly $1\frac{1}{2}$ ounces. The Teck-Hughes some while back gained the distinction of producing an ounce of gold at the lowest cost of any mine in the world, a proud position that it has continued to hold.

A further point that tended to keep interest alive was the character of the mineralization and the presence of tellurides, several varieties of which occur. Some of these are precious and some are not; but a very appreciable amount of the gold recovered is in combination with tellurium, which was supposed to have an adverse effect upon the metallurgy. More recent practice, however, has somewhat discounted this belief.

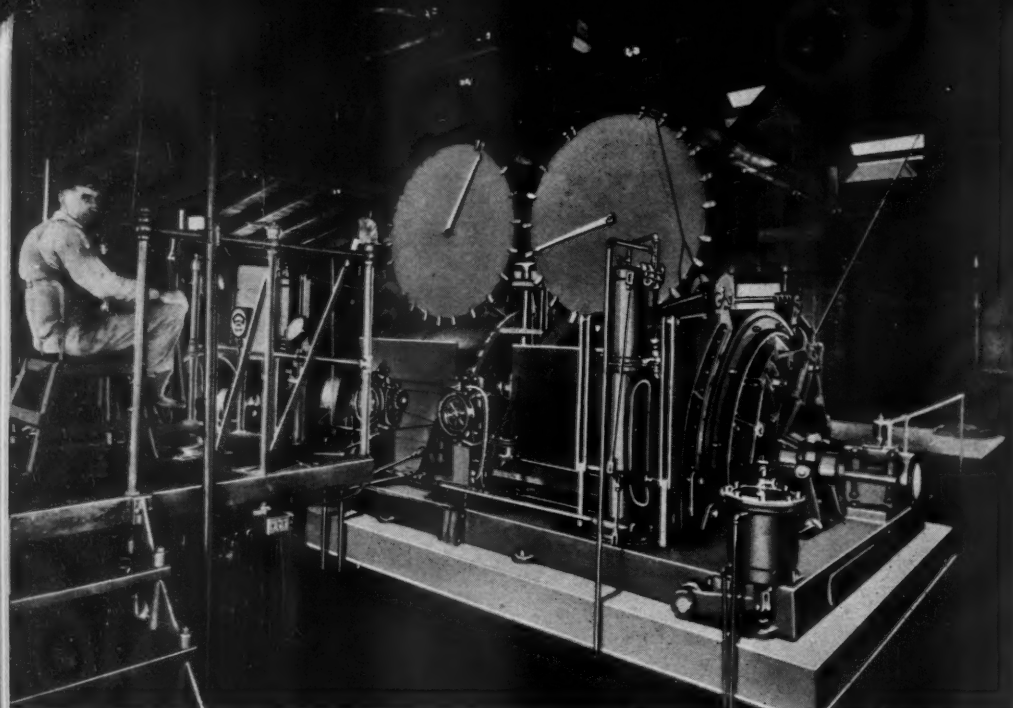
Turning once more to matters of record we note that mill capacities were increased in most cases as underground developments justified it. Today, the Lake Shore is milling in excess of 2,300 tons per day; Teck-Hughes, 1,300; Wright-Hargreaves, 1,000; Sylvanite, 325; and Kirkland Lake

SYLVANITE MINE

This property started operations in 1913, taking over some of the claims of W. H. Wright. For a time the mine showed little promise, but it rounded into a good producer and has con-

tributed something more than \$6,000,000 to the world's gold supply. Values are holding up well with increasing depth. There is now being milled about 325 tons of ore daily.





Gold, 150 tons. The Tough-Oakes, after being closed down from 1918 to 1921, resumed work in 1922, and then ceased operations again in 1928. In 1931 interests associated with the Premier Mine in British Columbia took it over. Production under the new ownership was started in 1932 and has continued since under the name of Toburn Mines, Ltd., with a daily capacity of 100 tons.

Another and later development of the camp was the Macassa Mine which lies directly west of Kirkland Lake Gold. This property was staked in 1912; but for many years nothing was made of it. Finally, however, in 1933, it was brought to production with a 200-ton mill and under the leadership of R. A. Bryce. There are now seven mills in operation along the Kirkland Lake belt proper, and these have a combined capacity of about 5,425 tons of ore per day. Adjacent to the main belt are such properties as Bidgood and Barry-Hollinger, both of which are active.

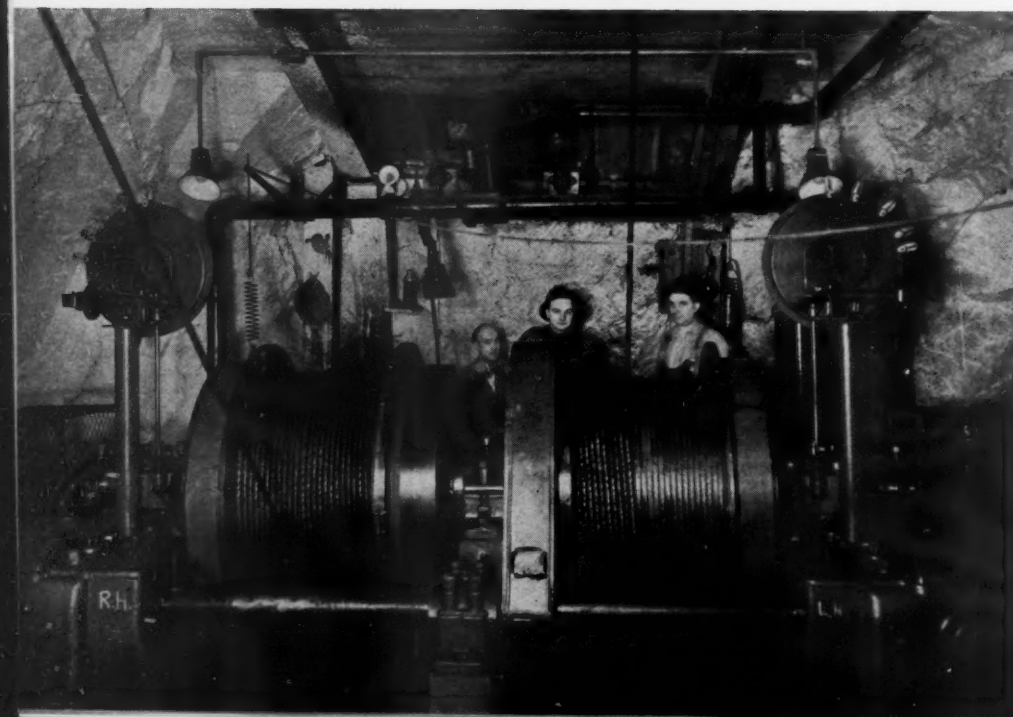
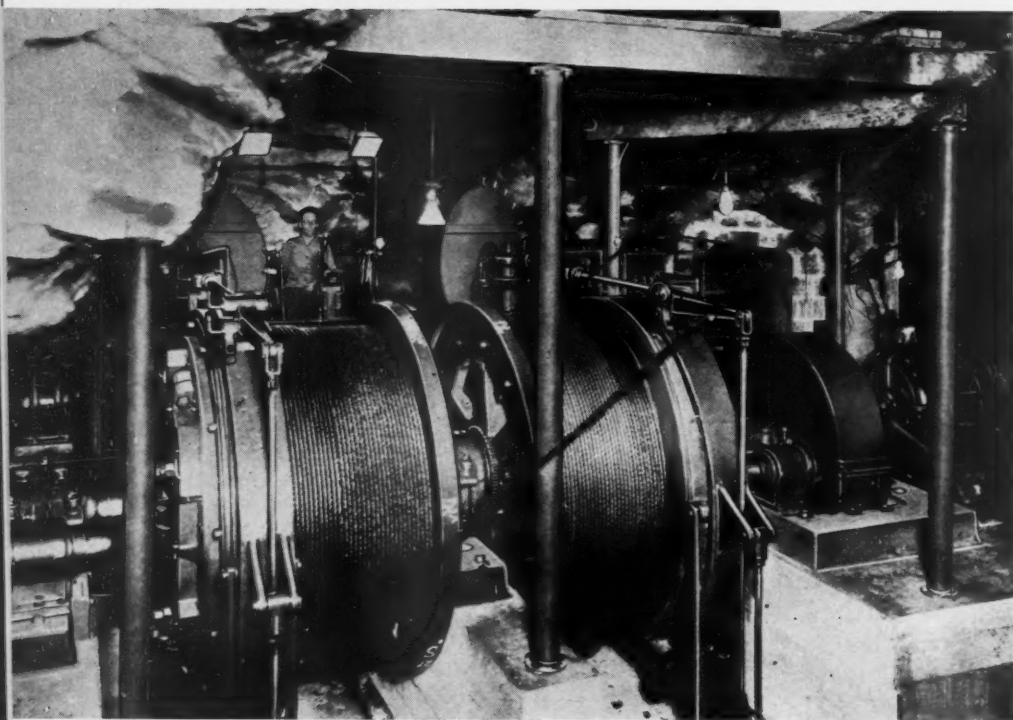
The Kirkland Lake camp has pioneered in deep mining in Canada, and Kirkland Lake Gold as well as Teck-Hughes are working at levels nearly 6,000 feet below the surface. Lake Shore has an internal shaft that extends from the 4,325-foot level of No. 1 Shaft to depths equalling those of the mines previously mentioned. Wright-Hargreaves and Sylvanite are both down about 4,000 feet. It should be noted, however, that large quantities of ore originate from the upper levels.

Rapid deep development has been a feature of the camp, and was considered advisable because of the comparatively short lengths held by each company on the ore-bearing zone. It has taught us a great deal about the deep-seated nature of gold deposits in the Pre-Cambrian; and it is now generally conceded that the limits of deep mining in well-established gold camps will be imposed by economic factors rather than by any limitations attributable to the genesis of the ore bodies.

LIFTING ORE BY STAGES

These three pictures furnish an interesting example of how ore is hoisted in the Kirkland Lake District. Stage hoisting is the usual practice where mines reach deep levels, as it provides a more flexible and less expensive arrangement than one hoist of a size sufficient to handle the loads in one lift. All of these hoists are installed on the property of Kirkland Lake Gold Mines, Limited. The one shown at the top was put in service at the surface in 1924. It is an electric-driven unit, with a rope speed of 1,000 feet per minute and a rope pull of 12,500 pounds. In 1928 the mine had been deepened to the point where another hoist was required, and the electric-driven unit shown in the center was installed on the 2,475-foot level. The two hoists, working in series, sufficed until about two years ago, when further deepening necessitated a third hoist, which is shown at the bottom. It is an air-driven unit and is installed on the 4,975-foot level. All three hoists were built by Canadian Ingersoll-Rand Company, Limited. The mine is now down approximately 6,000 feet.

Compressed Air Magazine



Kirkland Lake has produced gold to the value of \$167,214,477 (at the statutory price) during its history. This, together with exchange adjustments of \$25,067,557 due to the higher price of gold, gives a total of \$192,282,054. Output of the major mines up to the end of 1934 (with gold at its statutory price) was as follows:

Lake Shore Mines, Ltd.....	\$73,804,175
Teck-Hughes Mines, Ltd.....	44,379,562
Wright-Hargreaves Mines, Ltd.	29,958,149
Sylvanite Mines, Ltd.....	6,350,639
Kirkland Lake Gold.....	4,895,906
Tough-Oakes (now Toburn)...	4,014,247

These figures summarize, in the cold, brief way that figures have, what these great mines have accomplished; but there are many things that they do not tell. For instance, there is the fact that Kirkland Lake soared to its greatest production heights from 1929 onward, just when Canada needed most the stimulus of the wealth they created (nearly \$130,000,000 of the camp's total yield has been obtained since 1929). Another point that they do not bring out is the amount of thought and effort that has gone into the making of Kirkland Lake. It has never been an easy camp.

In this abbreviated review we have given some account of its vicissitudes; and it is obvious that the unraveling of its problems must have been difficult. That is one of the reasons why Kirkland Lake has held its men. Those that went there in the early days have never been able to look around and say "my work is done," and move on to other enterprises. Many of them have stayed on fighting each obstacle as it arose, and some of them have grown old in its service.

There is Dr. J. B. Tyrrell, who took charge of the destinies of Kirkland Lake Gold a good many years ago and who through force of circumstances and geological reasoning became the father of deep mining in the Pre-Cambrian. There is W. Sixt, who managed the property for a long time and who recently retired and gave his place to Victor Emery who used to be with Hollinger. In 1918, Dr. D. L. H. Forbes took hold of Teck-Hughes, and made it the lowest-cost producer of an ounce of gold in the world. He still directs the mine as president; and R. J. Henry, after assisting Doctor Forbes for many years, became its general superintendent.

Also in that group of pioneers are James Grant, who handled Wright-Hargreaves in the early days, and M. W. Summerhayes, who made it a great mine. There is Harry Oakes who drove stakes into the Lake Shore, who still controls it, and who only two or three years ago relinquished the position of managing director to A. L. Blomfield, who came to the mine after long experience in other lands. There is E. W. Todd, who used to be a geologist for the Ontario Department of Mines, who wrote a report of the Kirkland Lake Gold Area that is a classic, and who is now general superintendent of



LOADING ORE UNDERGROUND

Feed chutes from which ore is run into pockets which measure it into hoist skips at the Lake Shore Mine. The chutes are operated by means of hand wheels.

DRILLING SCENE

An N-82 drifter drill operating on the 400-foot level of the Sylvanite Gold Mines, Limited. The mines in this district are characterized by extremely hard rock which has demanded drills of high efficiency.





REFINING GOLD

A fortune of great size has passed through these plain-looking furnaces that are used for taking impurities out of the gold at the Teck-Hughes property.

Lake Shore. There is Earl Rodgers, of the Sylvanite, who nursed his mine along and finally made it an important factor in Kirkland Lake. These are only a few of the men who have contributed to the success that the camp has achieved. There are many others in the mines and mills; but space prevents cataloguing them and their accomplishments. Most of them, however, have been there from the start, and they have given the best years of their lives to the development of the mines with which they are associated.

And so we come to the end of the third phase of this history. Up to now we have shown how the mineral discoveries since

Cobalt have followed step by step, and how each begot the next by providing a fresh urge to seek and by establishing a base for further exploration. It was inevitable that Kirkland Lake should also serve such a purpose. It was the real beginning of the movement eastward that finally resulted in the development of northwestern Quebec. The events that transpired there will form the subject of our next chapter, but before turning to the contemplation of those somewhat riotous matters it must be remarked that our review of Kirkland Lake, like that of Porcupine, is an unfinished story, for it, too, is still in the heyday of its productivity and can look far into the future. Its past,

as has been brought out, has known its uncertainties, and its present is the outcome of a stubborn belief in its possibilities.

The full measure of the present can be grasped by any observer who stands on the high ground around the Toburn Mine. Stretched before him is the busy town, and silhouetted against the sky is the long line of headframes. It is a scene of strict utility, and it really needs the gloom of dusk, when the lights of the mills glitter tier upon tier, to give it a sort of restless beauty. If you stand there in the twilight, as this writer has done, you will pay a silent tribute to the men whose tenacity of purpose created and developed the plants that are pouring created wealth into the lifeblood of Canada. In the light of the present the early days of stress and strain seem far away and dim, and it is easy to forget all the effort that has gone before; but the past is an undeniable fact, and one may well wonder what was the driving force that made men persevere in the face of seemingly unfavorable conditions. The writer found the answer thereto a short time ago when W. H. Wright, who first discovered gold at Kirkland Lake, said: "I have so little time for the past, there is so much in the present, and so much to think about in the future." That is the spirit which made Kirkland Lake, which has, in fact, made the whole North Country.

THE PIONEER MINE

The Tough-Oakes, now the Toburn, was staked in January, 1912, by Harry Oakes and the Tough brothers. Later Oakes moved on and discovered the Lake Shore, now one of the richest mines in the world. The Tough-Oakes is still producing and credited with an output of more than \$4,000,000.

This is the sixth of a series of articles by Mr. Rowe. The seventh will appear in an early issue.



IN THE far northwestern corner of the United States, in the waters of Puget Sound, are the San Juan Islands. Beautiful green gems, set in a sea of blue, they impress the visitor with their scenic splendor. Heretofore the only means of reaching them has been by boat, as none had been considered well enough developed to justify the cost of a bridge. For many years, however, the residents of Whidbey Island, the largest of the group, have talked and dreamed of such a connection with the mainland. That hoped-for bridge is now under construction across Deception Pass, and will link Whidbey Island with Fidalgo Island via Pass Island. Fidalgo Island can hardly be called such, as it is separated from the mainland only by a slough that was easily spanned.

Whidbey Island, together with its environs, was explored in 1792 by a party of British under Capt. George Vancouver. It was named after Joseph Whidbey, master of one of Vancouver's ships. True, the Spanish and the Dutch may have been there previously; but that did not prevent the British from renaming some of the geographical features discovered by the Spaniards in the New World. On June 4 of that year, with appropriate ceremonies and in honor of the birthday of George III of England, Captain Vancouver took possession of this part of the new land in the name of his sovereign. All this happened at what is now the site of the City of Everett, which lies east of the southern end of Whidbey Island and is separated from it by a narrow stretch of water.

The early settlers of the island, hewing their homes in the wilderness, were often beset by Indian marauders from the North. Old blockhouses are still standing there as a reminder of those pioneer days. How well they cleared the land and cultivated it is evidenced by the fact that some of the existing farms are striking examples of the best that the Puget Sound country can offer. The soil is very fertile, and this has brought fame to the island in the form of one world and two United States records in wheat production. The former was won with a crop of 117.5 bushels to the acre. It also has a reputation for its berries, chickens, and dairy products.

Now that the handicap of transportation is being removed by the building of the

Deception Pass Bridge

Deception Pass Bridge, it will be possible to get the produce to market quickly; and it is to be expected that "Paradise Island," as the Indians called it, will develop rapidly in consequence. It is likewise known as "Long Island of the West," extending as it does for a distance of 60 miles and ranging in width from one to twelve miles. It is said to be the second largest island in the United States.

The contract for the crossing was let by the State of Washington under the PWA and with the counties of Skagit and Island cooperating. It was awarded on a bid price of \$304,755 to the Puget Construction Company of Seattle, Wash. The crossing really will consist of two bridges—one from Fidalgo Island to Pass Island spanning Canoe Pass, and the other from Pass Island to Whidbey Island across Deception Pass—and of a short connecting link on Pass Island. The first named is a 450-foot steel arch structure and is already standing, the second will be a 900-foot steel cantilever bridge, and the connection will be constructed of concrete slabs and will have a length of 22 feet.

Where the crossing is taking form, both Whidbey and Fidalgo islands present sheer bluffs of solid rock, while the intervening small Pass Island rises precipitously above the surface of the water. Because of these natural advantages, it was possible to excavate all the pier foundations in the sides of the cliffs and at points well above high-water level. This phase of the activities has involved the removal of 3,300 cubic yards of rock.

Before work on Pass Island could be started it was necessary to connect it by cableway with near-by Fidalgo Island.

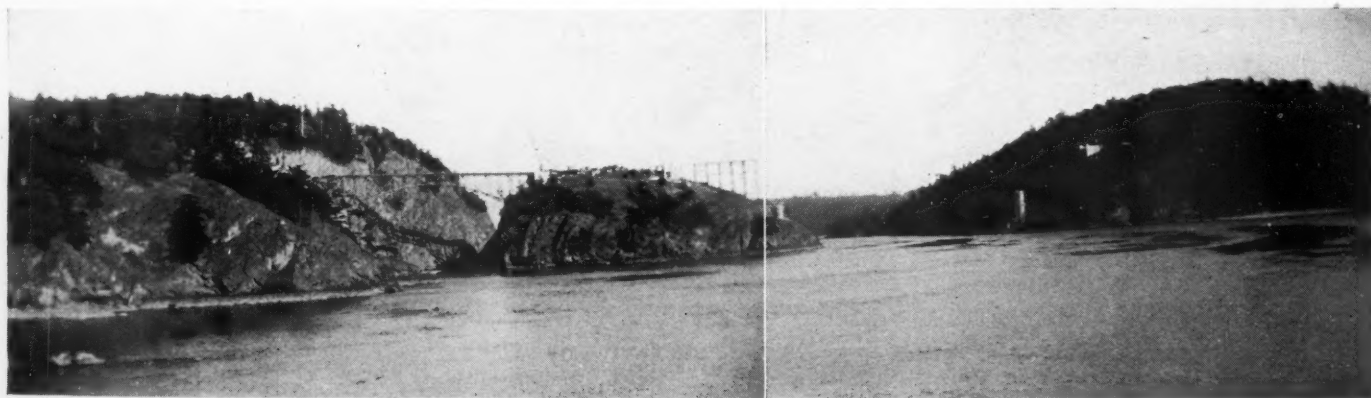
This cableway was operated by a gasoline engine and served to transport cement and aggregates for the Pass Island piers and approaches as well as structural steel for that end of the Canoe Pass bridge. A stiff-leg derrick with an 85-foot steel boom was used there to handle and to place materials.

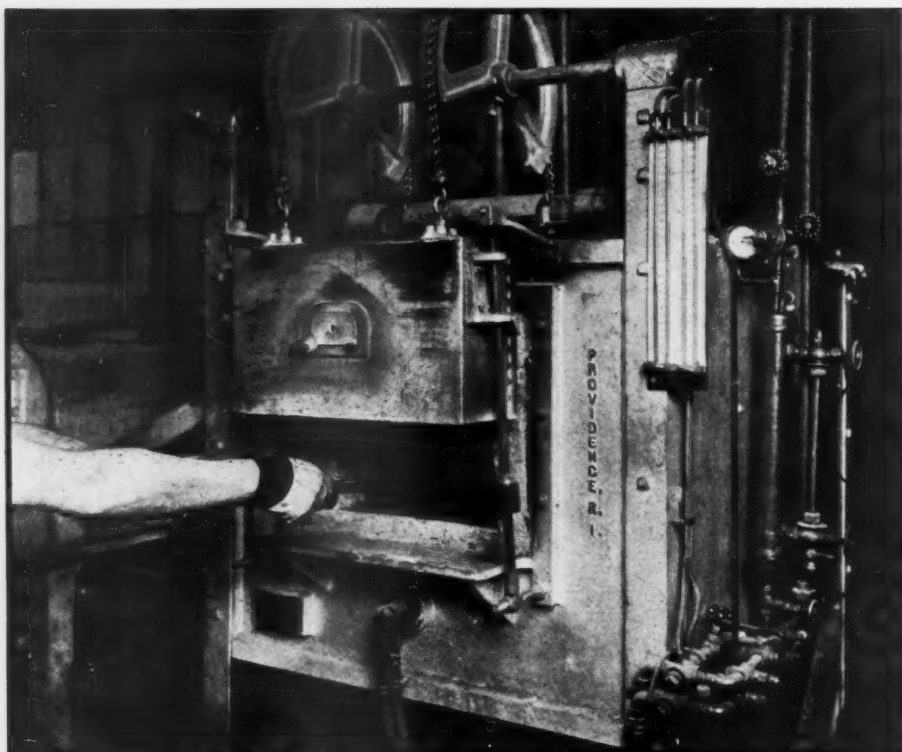
As soon as the first link with the mainland was established, a light railroad was run across the 450-foot span to do the hauling for the Pass Island end of the cantilever bridge. Small cars are employed on the line and are drawn by a tractor with flanged wheels. The materials and supplies for the Whidbey Island end of the structure are taken by barge to Cornet Bay and then transported for a distance of three miles to the building site.

All told, the contract calls for the use of 4,000 cubic yards of concrete, inclusive of the approaches, and of 3,240,000 pounds of steel: 955,000 pounds for the Canoe Pass Bridge and 2,285,000 for the cantilever bridge. Compressed air for riveting and also for spray painting is being furnished by an electrically driven Ingersoll-Rand 360-cfm. compressor of the stationary type. Paul Jarvis and John F. Ward are in charge of the work for the Puget Construction Company, with H. F. Donnelly acting as resident engineer for the State Highway Department.

From end to end, the crossing will be 1,372 feet long and will be flanked with 3-foot sidewalks for pedestrians. Its deck will be at elevation 180, thus assuring ample clearance for ships which can navigate Deception Pass at slack-water periods. When the tide is running, however, this is out of the question, as the constricted channel is turned into a raging, foaming torrent.

Aside from its economic aspects, the bridge will make accessible to the traveling public a region of great scenic charm that has long attracted fishermen and nature lovers. On either side of it lies Deception Pass State Park with the towering Olympic Mountains to the west and the Cascades to the east, both capped with snow the year round. This playground has recently been provided with added picnic and camping facilities to accommodate the large number of visitors that are expected as soon as the structure is open to traffic.





FLAME CURTAIN

Through a slot in the bottom of this electric furnace, just inside the door, a curtain of flame is directed across the opening to prevent oxidation of materials being heated. At the right of the furnace is the apparatus that serves to reduce the air pressure from the plant line, to mix it in the correct proportions with gas, and to extract the moisture. On the front of the furnace, at the right, is a manometer which indicates the pressure of the fuel mixture.

Compressed Air Aids Manufacture of Machine Tools

WITH its diversified uses, compressed air is a valuable aid in any machine shop. Its full worth probably never is realized until the supply happens to be cut off for a few days. That eventuality fortunately seldom occurs, thanks to the dependability of modern compressors. The larger the manufacturing plant, the greater is the need of an adequate compressed-air

Fred B. Jacobs

system. Two plants rarely have exactly the same air equipment and seldom use it for exactly the same purposes. This article illustrates and describes a few representative applications of compressed air in the plant of the National Acme Company, Cleveland, Ohio, manufacturers of precision machine tools. This establishment is one of the largest of its kind, with floor space of ten acres and about 2,000 employees.

Compressed air is used freely throughout all the shops. The compressing equipment consists of a 2-stage, 1,000-cfm. machine which supplies air at 100 pounds pressure to a receiver, from which it flows through

fifteen miles of pipe lines to various outlets. For night work, when the demand for air is not heavy, a 500-cfm. compressor suffices. Three other small compressors are also installed for service when required.

Any machining operation produces a large amount of chips which must be cleaned away before the part in process of manufacture is tested for size and removed



CLEANING

Compressed air provides a quick and effective means of cleaning away chips, filings, and other metal particles. Every machine tool in the plant described is served by a compressed-air outlet. In the sub-assembly line (right) there is an air line for each two benches. The nozzle is fitted with a shut-off, while the hose is connected with the delivery pipe by a quick-acting quarter-turn coupling.



INSPECTION

The woman is checking parts for size by means of a special gauge. It is imperative in this work of inspection that the parts be clean. Slightly to the left of the operator's left hand is a continuous compressed-air blast, with a deflector plate above it. It is a simple matter to remove dirt or other adhering substances by passing the parts over this air stream.

from the machine. Under ordinary conditions, the workman uses a brush, but that method is never quite satisfactory. Compressed air is the solution of such cleaning problems. All that is necessary is to direct the air nozzle toward the work and press the release that opens the valve. Each machine tool in the plant is equipped with an air nozzle with sufficient hose to reach all parts of the machine.

Compressed air is a valuable aid on the sub-assembly line, where the various parts are put together before they are incorporated in finished machines. The assembly benches are installed back to back. Thus one air hose dropped from an overhead supply line serves two benches. On the bench assembly line compressed air is used for removing chips left after filing and chipping, for cleaning out drilled, reamed, and tapped holes, and for drying parts that have been washed in gasoline or other solvent to remove grease. At the end of each day each workman cleans his bench with air so that the shop always presents a tidy appearance.

In the manufacture of any precision machine tool, certain parts of which must be timed to function with accuracy in connection with other parts, it is often necessary to drill and to ream holes for taper pins in the course of their assembly. For such



services portable tools are required, and these are operated with compressed air. On the floor assembly line there are always anywhere from 10 to 30 machines in various stages of completion, and as compressed air is drawn on freely in this department for different purposes, outlets for it are located at frequent intervals. In addition, several hundred feet of hose is available and permits operating the tools wherever they are needed. Compressed air also is used effectively on various inspection lines, for it is impossible to examine work that is not cleaned thoroughly. Without its aid, the pieces would have to be cleaned before

they are handled by the inspector, which would mean a separate operation.

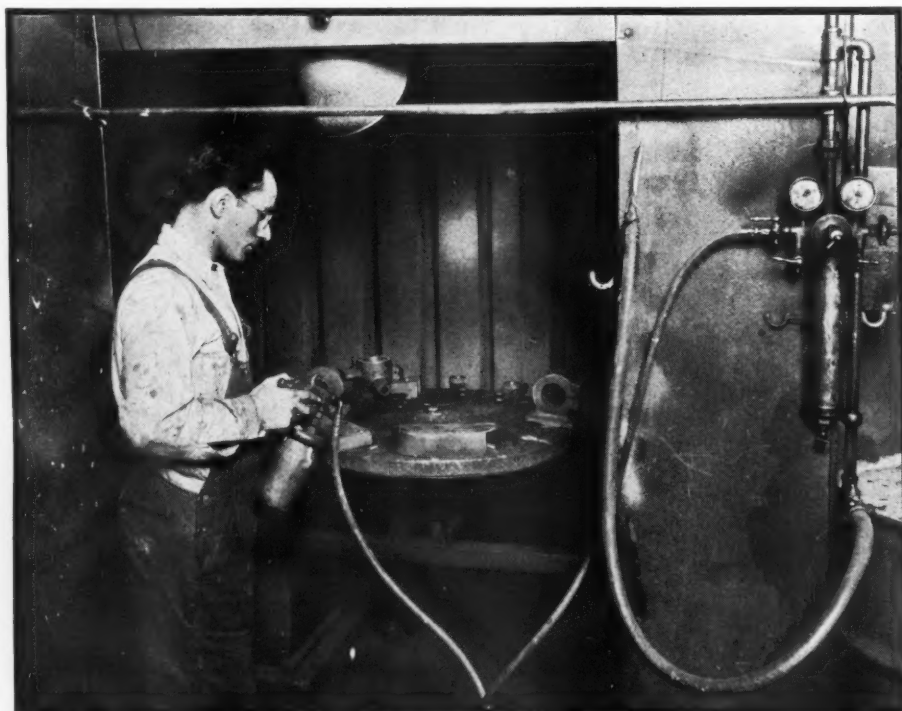
Automatic machines made by the National Acme Company are finished in the standard machine-tool gray adopted some years ago by the National Machine Tool Builders' Association. In the paint department, compressed air saves valuable time, for without it the workmen would have to resort to grandfather's paint pail and brush method. Some of the larger paint booths can accommodate an entire automatic screw-machine frame.

Compressed air plays an important part in the heat-treating department, particularly in supplying the necessary air for flame curtains on Hays electric furnaces. Issuing from a slot just back of the open door is a flame curtain, the object of which is to keep the heated work in the furnace from becoming oxidized. The use of such flame curtains is fast becoming standard practice in up-to-date heat-treating plants, and without compressed air under accurate control it would be impossible to maintain them.

While the foregoing are only a few of the many applications of compressed air in a large machine-tool manufacturing plant, they will bring to the mind of the practical man many instances where compressed air can be used to advantage.

PAINTING

Parts, as well as complete machines, are painted a standard gray color. Air brushing saves valuable time and insures an even application of paint. This picture shows one of the smaller booths where parts are rotated on the turntable to facilitate the operator's work. Compressed air is drawn from plant lines and reduced to the desired pressure.





A MAN WHO PERSEVERED

GUSTAV Lindenthal, pioneer American engineer who died recently, left many long-enduring structural monuments to his technical talent, but he passed on without realizing his fondest dream. For more than 40 years he urged the construction of a single-span bridge across the Hudson River to link the New Jersey shore with the heart of Manhattan. Many times it seemed that he was on the verge of success, but something always happened to thwart his efforts.

True, he reaped a partial measure of vicarious victory, for the great George Washington Bridge was executed by one of his former pupils, O. H. Ammann, now chief engineer of the Port of New York Authority. To the end, however, Mr. Lindenthal persevered in the conviction that he could attain his major ambition of a bridge farther downstream; and although far past the allotted three-score-and-ten years, he continued actively and unceasingly to strive for it. Probably some day the bridge will be built. If it is, Mr. Lindenthal's name may not be mentioned on any tablet that shall grace it, but he will, nevertheless, have been the man responsible for it.

Born and educated in Austria, Mr. Lindenthal came to this country at the age of 24. He had a hand in designing the buildings for the Centennial Exposition in Philadelphia, then hired out as a bridge engineer in the Pittsburgh area. In 1881 he established himself as a consulting engineer and designed numerous Pittsburgh bridges which are still important in that city's traffic and transportation system. A few years later he was retained to find a way for the Pennsylvania Railroad to enter New York City. He suggested a bridge and sought to interest all the major railroads in it. A charter was secured from Congress, but the 1893 panic delayed construction. Most of the railroads were bankrupted, and when the Pennsylvania resumed consideration of the problem it elected the less costly plan of tunneling. Thereafter, Mr. Lindenthal many times

secured financial backing for his cherished project, but War Department rulings were unfavorable to it.

Meanwhile he continued to conceive many notable bridges, chief among them being the famous 977-foot arch at Hell Gate for the railroad that connects the New Haven and Pennsylvania systems, a structure on which he had the collaboration of Samuel Rea, then chief engineer of the Pennsylvania Railroad. It was on that work that Mr. Ammann served as an assistant engineer. At 75 Mr. Lindenthal directed a large bridge-building program in the Portland, Ore., area. He was the last of the old guard in his line—a group that contributed inestimably to the engineering and construction advancement of the nation.

THE ENGINEER'S PLACE



THE puzzled world needs engineers today more than at any period in her history. She needs their knowledge, their optimism, and their courage. Kings may fall, premiers may be denounced, presidents become unpopular, dictators lose their heads, but the engineer will still be vital to the happiness and existence of mankind."

OUR COVER PICTURE

Outstanding among the mechanical facilities at Grand Coulee Dam is the conveyor system for disposing of materials excavated at the dam site. It extends from the river bottom to Rattlesnake Canyon. Its initial length was $1\frac{1}{8}$ miles, but as the spoil pile grows longer this will gradually be increased to $1\frac{3}{4}$ miles. In the same manner, the height to which the materials are elevated will progressively grow from 350 to 550 feet. The conveyor has handled as much as 51,000 cubic yards of rock and earth in 21 hours.

These are the closing words of a paper by C. P. Browning, prominent Canadian mining engineer, as presented in the July issue of the *Canadian Mining and Metallurgical Bulletin*. Coming from Mr. Browning the remarks bear added weight, for by exercising the very qualities which he cites he kept the Britannia Mine at Britannia Beach, B. C., in operation in the face of great odds. For that accomplishment he was awarded last year the Randolph Bruce medal which is annually given for the most notable contribution to mining practice in Canada.

The engineer's position, Mr. Browning believes, is today the most difficult, the most contradictory and problematic of any member of society. On one side of him are the so-called capitalists, the employers, demanding his loyalty and ingenuity; on the other side are the workmen, requiring sympathy and understanding. When he makes a decision, the two forces meet. He must produce for one with justice to the other. To make profits under such conditions is a truly gigantic problem. In the light of the changes which the world is undergoing, Mr. Browning concludes that the technical skill of an engineer is continually becoming subordinated to his ability to understand and to handle human beings. Mere efficiency is no longer enough; human engineering has taken an important place in all industrial relations.

Despite the troubles that beset the engineer, Mr. Browning thinks him equal to the occasion. "The public," he says, "always has depended upon and trusted the engineer. For king and Pharaoh and Caesar, he built the tiled streets of Babylon, the pyramids of Egypt, and the aqueducts of Rome. In all the changing centuries he has been the one fixed star in the universal heavens. In times of peace, he has constructed for the world her greatest treasures. In times of war, he has been the first to offer of his knowledge. Russia, today, in her great experiment recognizes that the engineer is indispensable to her success. She has borrowed from us, eager for our skill."

This and That

Boulder Dam at Work

Although the Colorado River reached a flood stage of 105,000 second-feet in June, farmers in Imperial Valley, Calif., did not experience their annual anxiety. This because Boulder Dam had begun its work. The huge expenditures that have been made periodically to repair levees and clean irrigation ditches of silt are at an end. Fear of drought is likewise over. Scarcity of water cost Imperial Valley \$10,000,000 last year; this year Boulder Dam Reservoir contained enough water at the end of July to supply all the needs of the valley for the year. At that time, the reservoir had become the largest artificial lake in the world, having exceeded Assuan Dam Reservoir, the previous record holder. It was deeper than Lake Erie, although filled to only one-seventh of its capacity.

Record Boring Speed

Reports of new records of speed in tunneling appear with increasing frequency. It is difficult to determine the validity of many of these claims, because of variations in the types of material penetrated and in the sizes of the bores. There can be no question, however, about the authenticity of the mark recently set in the Midtown Hudson Tunnel between New York City and the New Jersey shore. The progress registered there far surpassed any previous speed in driving a shield tunnel under compressed air. Furthermore, the cross section of the opening was larger than in the case of former record holders. The 32-foot shield which started from Weehawken early in the year reached the Manhattan bulkhead on August 2, almost four months ahead of schedule and about two months earlier than had been predicted by Supt. George B. Montgomery, the country's most experienced soft-ground tunneler. In a single day an advance of 47½ feet was registered, which means that nineteen complete rings of segmental cast-iron lining were assembled behind the shield. The best record for a month was 1,042½ feet.

As the *Engineering News-Record* notes, the making of fast progress through the Hudson River silt was the result of the discovery that most of it could be pushed aside and that it was necessary to take into a shield only sufficient material to ballast the tube being progressively assembled behind it. One of the principal contributions to the speed maintained by Mason & Hanger Company in this latest bore was a hydraulic wrench which ran up the nuts on the bolts holding

the lining segments together. This operation was formerly done by hand.

A description of the Midtown Hudson Tunnel construction was published in our April, 1935, issue.

Oil From "Depleted" Fields

A means of producing petroleum from fields that can no longer be worked profitably by the usual methods is reported to be giving encouraging results in Russia. It is a variation of the well-known repressuring system, the principal difference being that heat is introduced to increase the fluidity of the oil and to dissolve congealed deposits in the interstices of the reservoir rock.

Wells are worked in series of three or more. Into one of them fire is introduced, either in the form of burning coal or coal gas. Oxygen to support combustion is supplied by compressed air at 90 to 100 pounds pressure. When combustion has extended to the oil and is well established, the air pressure is reduced to 30 or 40 pounds—the heat serving to “crack” or break up the petroleum into gas and an oil lighter and more fluid than the original deposit. Gas and, later on, oil issue from wells other than the one into which the air is being forced. The gas is of an enriched quality and high in heating value. It is stored in gasometers and then put to use. The oil is collected and refined by conventional methods.

American petroleum engineers experimented with a similar process for prolonging the lives of oil fields many years ago, but came to the conclusion that it was not practical while there was so much flush production in the country. The Russians,

however, seem satisfied with the progress they have made and believe that, with greater development, the heat-and-pressure method will make it possible to recover vast additional yields from areas that have been virtually abandoned. It is known that only approximately half of the contained oil is now obtained from the average field.

Who Built Boulder Dam?

Arguments that large Government-financed construction projects benefit only the sections of the country in which they are located will not hold water. Additional evidence that their immediate benefits are in reality widespread is furnished by a tabulation of the principal expenditures in connection with Boulder Dam. It shows that more than \$10,000,000 went to Barberton, Ohio; more than \$2,000,000 to each of Schenectady, N. Y., and East Pittsburgh, Pa.; almost \$2,000,000 to Milwaukee, Wis.; and lesser but very sizable sums to Denver, Colo.; Gary, Ind.; Muskegon and Niles, Mich.; Chicago, Ill.; Philadelphia, Pa.; Elizabeth, N. J.; and San Francisco, Calif. The record reveals that every state in the union contributed materials for the dam itself or for accessory structures. It is impossible even to estimate the number of persons thus given work, but it undoubtedly ran into the thousands. The transportation of the products likewise increased employment.

The variety of materials that were used in building the dam is as remarkable as the wide distribution of the funds. Among them may be mentioned 86,968 hacksaw blades, 7,360 flashlights, 13,046 “hard” hats, 12,912 water buckets, 190,500 pounds of rags, 32,664 canvas water bags, 19,384 paint brushes, 23,144 pairs of rubber boots, 355,000 gunny sacks, 13,356 shovels, 495 miles of manila rope, 5,348 sponges, 20,232 sheets of emery paper, 96 fishing poles, and 588 police whistles.

Between February of 1931 and February 1935, Six Companies Inc. paid more than \$50,000 for supplies to each of 47 firms. They bought nearly 5,000,000 gallons of gasoline, more than 500,000 gallons of lubricating oil, and more than 750,000 pounds of greases. During the same period, the Government expended more than \$20,000,000 for cement, steel, and machinery, and had \$22,000,000 of purchases remaining to be made. All told, 27,092 carloads of materials arrived in Boulder City during the 47 months reported on. As the *Reclamation Era* points out, Boulder Dam was, indeed, a national job.



“Boy, what yo’ talkin’ ’bout? I know dat tire weighs more dan any hundred pounds, fo’ hits got eighty pounds of air in hit.”

Industrial Notes

One of the new products of the Alemite Corporation, Chicago, Ill., is a portable pneumatic power gun that has been especially designed to meet the lubricating needs in the construction field.

Sodium-vapor lamps to the number of 1,000 are to provide illumination for the great San Francisco-Oakland Bay Bridge. The type was selected because of its high efficiency and freedom from glare, a combination making for increased safety and comfort.

At the recent annual meeting of the American Railway Engineering Association in Cleveland, Ohio, the masonry committee adopted the term "shotcrete" for pneumatically applied concrete or mortar to avoid conflict with copyrighted names for materials falling within this general classification.

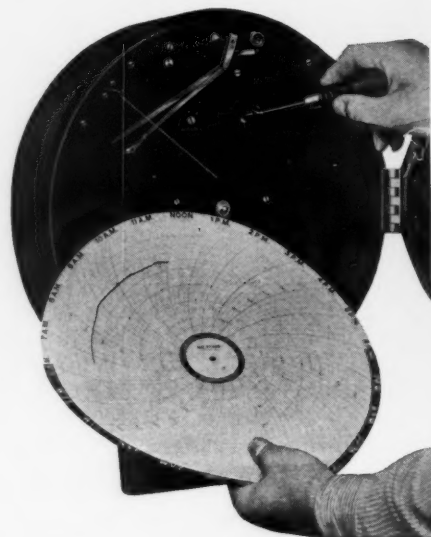
What might be called a hospital for recording instruments is maintained by Instrument Rebuilders & Repair Company, a new concern that prides itself on having established a new industry. It takes obsolete, broken, or inaccurate instruments and puts them in first-class working condition in its plant located at 611 Adams Street, Hoboken, N. J.

The Fostoria Pressed Steel Corporation is offering for general industrial use a sealing material that was originally developed for the U. S. Army Air Corps. It is claimed for this product that it prevents leakage of gas, vapor, oil, gasoline, steam, water,

grease, alcohol, and anti-freeze and other solutions; that it does not harden nor dissolve; and that it is proof against vibration, shrinking, and cracking. It comes in three weights for specific purposes.

As the result of research, sponsored by the Engineering Foundation, Prof. Philip B. Bucky, of the Columbia University School of Mines, New York City, has developed a machine for testing models of dams, mine supports, etc., to determine possible weak points in advance of building. The invention is a combination centrifuge and photoelectric apparatus in which a model is placed and whirled. While thus revolving, centrifugal force exerts stresses upon the small structure akin to those that gravity would exert upon the large-scale structure, and a moving-picture camera records the behavior of the model the while. The film brings the danger spots to light and makes it possible to redesign a structure where needed to give it added strength.

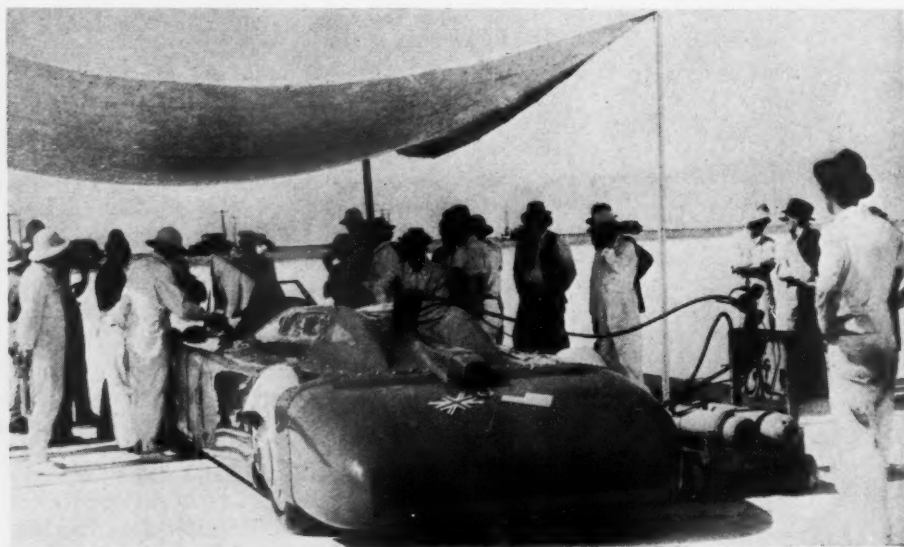
On the occasion of its seventy-fifth anniversary, The Brown Instrument Company announces a new and complete line of air-operated recording and indicating controllers for temperature, flow, pressure, and liquid level. Especial emphasis is placed upon its Air-o-line, an instrument that corrects for the magnitude, rate, and direction of departure from the control point and is said to be capable of maintaining a process at that point within extremely close limits. It has a 1 to 150 per cent throttling range and an automatic reset, the dials of both of which can be adjusted easily with a



screwdriver without removing the chart plate. The complete list of the new products is too long to give it space here; but all the instruments are described in Catalogue 8900 that can be obtained by addressing the company at Wayne and Roberts Avenues, Philadelphia, Pa.

A small temperature gauge that is designed to perform the same service on various classes of machinery that the dash gauge does on an automobile is being made by the Ideal Commutator Dresser Company of Sycamore, Ill. It consists of a dial plate mounted in a dustproof aluminum case which is fitted with a nonbreakable crystal. The dial provides for temperature readings from 0° to 100°C., and has a background divided into green, orange, and red sections to indicate safe, caution, and danger zones. The instrument screws into a baseplate which is attached with escutcheon pins to an air-compressor cylinder, motor, pump, or other machine. The new product, which is known as the Ideal Tel-Temp, can be used for either temporary or permanent service.

Electric "Tugger" Hoists is the title of a 44-page bulletin recently published for free distribution by Ingersoll-Rand Company, New York, N. Y. It lists and describes the company's single- and double-drum hoists, including such new products as a double-drum hoist of 100 hp., single-drum car-pulling hoists, oil-engine-driven double-drum hoists, and gasoline-engine-driven single- and double-drum hoists. It also contains numerous installation views and plans for the assistance of users and potential users. Hoists of this type have manifold applications in mines, quarries, sand and gravel pits, cement mills, on boats, docks, and elsewhere where hoisting, scraping, dragging, etc., have to be done. A copy of Bulletin 1860 will be sent to anyone interested upon request.



International News Photo

STARTING THE BLUEBIRD

Compressed air was used to start the 12-cylinder automobile in which Sir Malcolm Campbell on September 3 roared over the Bonneville Salt Flats in Utah for a new land speed record of slightly more than 300 miles per hour. The picture shows high-pressure air being fed into the engine through the hose leading from the two steel cylinders at the right.